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Kariba lake and dam

ON the 17th May 1960 Queen Elizabeth the Queen Mother will officially open the Kariba hydroelectric scheme in the Federation of Rhodesia and Nyasaland. The photograph on this month's cover shows the 420 ft-high dam across the Zambezi at Kariba Gorge, with the lake forming in the background. The control room and 330 kV switching station on the hill to the left of the dam are above the underground power station.

The first 100 MW set was commissioned in accordance with the original programme on the 1st January 1960 when power was supplied over the 330 kV transmission system to the Copperbelt; stage I, with a total capacity of 600 MW, will be completed in May 1962; plans for stage II envisage an additional 900 MW.

This great project is being assisted by a loan of $80 million from the World Bank, whose methods of operating are explained in an article starting on p. 215 by P. J. Squire

Secretary W. K. BRASHER, C.B.E., M.A., M.I.E.E. *Editor* W. G. ASKEW, M.C.
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SCIENTIFIC ADVICE TO GOVERNMENT

THE Advisory Council on Scientific Policy, whose 12th annual report appeared recently, consists of 15 members, of whom 13 are scientists or scientific industrialists, one is from H.M. Treasury and one is the Chairman of the University Grants Committee. Their advice is proferred to H.M. Government; they are therefore a very important body, and their reports are worthy of careful study.

Their current report, covering the year ended the 30th June 1959, is divided into five sections: scientific manpower; space research; National Lending Library of Science and Technology; U.S. agencies' research contracts at British universities and institutions; and overseas scientific relations. It is of interest to examine what the report has to say about scientific manpower and space research, two topics of extreme significance. First we take scientific manpower.

'A steadily increasing proportion of qualified scientists and engineers in our working population is essential if the United Kingdom is to compete successfully in a world in which the pace of scientific and technical development keeps on accelerating.'

This might be considered as the text from which the Council deliver their short homily on scientific manpower. They find that the demand for scientists and engineers shows no sign of abating; that a greater proportion of these people are finding employment in civil occupations (as distinct from defence); that the industrial range of these occupations is spreading; that the number of science teachers is increasing but not proportionately to the increase in the number of children studying science; and that great efforts will be required if the shortage of teachers is not to hinder the development of science courses at least in schools other than grammar schools.

Some noteworthy figures are given of the number of scientists and engineers in the United Kingdom who 'qualified' for the first time in 1958, i.e. graduated or were admitted to one of the professional institutions. The total was about 14600, of whom 5700 were scientists and 8900 engineers. The corresponding figures in 1955 were 5250 scientists and 6800 engineers.

A further breakdown shows that, in 1958, 6200 engineers were admitted for the first time to graduate or corporate membership of their institutions on the strength of qualifications other than a university degree or diploma.

The Diploma in Technology has yet to make its impact, but the number of students enrolled is growing, and, in engineering, the number of first-year students (853) is nearly eigh. times that of students in their fourth year (107).

The Council do not say whether or not they are satisfied with the rate of progress in producing scientific manpower, though they state, perhaps significantly, 'We cannot see any likelihood of the universities, and colleges of advanced technology, training in total more qualified scientists than will be needed'.

However, they strike a note of caution on the prospects of the average biology graduate without postgraduate training who wants to make a career in his own subjects.

We turn now to the Council's deliberations on space research.

The Council advised the Lord President that in their opinion it was desirable that the United Kingdom should embark on a scientific programme of space research by means of artificial earth satellites. The broad objectives of such a programme were: systematic study and measurement of the properties of the upper atmosphere, of solar electromagnetic radiation and other types of radiation reaching the earth's atmosphere, and of the earth's magnetic and gravitational field.

Since the production of modified British rockets might take five years, and would be very costly, it was recommended that the United States be approached with a view to participation in a joint programme, and

also that co-operation with the Commonwealth and collaboration with other countries be explored.

Later in the year the Government announced that design studies were being put in hand for the necessary adaptation of British military rockets, and the U.S. National Aeronautics and Space Administration offered to provide room in satellites for British instruments designed to carry out a scientific programme of the Royal Society, financed by the Department of Scientific and Industrial Research. Preliminary organizational work on this programme was in hand, and a Steering Group had been set up. The programme envisages an expenditure of between £100000 and £200000 per annum for the next few years, exclusive of the cost of launching vehicles or modification of British rockets.

The Council recognize the attraction of space exploration, but they again emphasize the importance of adequate expenditure on research and development in fields which are vitally important to the welfare of our people as well as for improving standards of living elsewhere. They add 'to leave these needs unsatisfied in order to shoulder the crippling cost of a large programme of space exploration on a purely national basis would be, in the Council's view, the grossest folly'.

They therefore advise properly co-ordinated international co-operative effort.

In this the Council may seem to have been rather timid. After recommending participation, they whittle it down to an expenditure of up to £200000 a year (exclusive of that on launching vehicles, for which they do not quote a figure). While appreciating the urgency of other researches in the interests of self-preservation and assistance to underdeveloped countries, we cannot escape the conclusion that, compared with a defence budget of well over £1500 million, £0·2 million is a paltry sum.

Prestige is something earned in the minds of others mainly through acknowledged individual achievement. Prestige is still important and, apart altogether from the considerable fringe benefits to industry from a more substantial space-research programme, it is something that this country would do well to earn. The state must preserve a balanced view in relation to the national circumstances, but it would seem that the effective expenditure of ten times the amount quoted above for space research could not possibly harm the other great needs and objects that the Council have so properly in mind.

Third International Conference on Medical Electronics, Olympia, London, 21st—27th July 1960

THIS Conference, which the Electronics and Communications Section, with the support of the Council of The Institution, are organizing in association with the International Federation for Medical Electronics, will provide a unique opportunity for members of the medical and electrical-engineering professions to meet and to acquaint themselves with the present state and rate of progress of the new, important and fast-growing field of medical electronics.

There will, of course, be many specialist papers primarily addressed to specialists but, in addition, there will be General Sessions comprising lectures, papers and discussions particularly intended to interest non-specialists from both the medical and the engineering fields, and to give them an up-to-date and comprehensive survey of all aspects of medical electronics and its applications.

National Co-ordinators for the Conference are serving in 23 countries oversea and are collaborating with the United Kingdom Organizing Committee in preparing a programme of contributions under the following main headings:

Instrumentation for medicine and biology
Medical electronics in space research
Isotopes and radiology
Ultrasonics and microwave radiation
The respiratory system
The digestive system, metabolism and biochemistry
The circulatory system
Electronic aspects of sight, hearing and locomotion
The motor and nervous systems
Obstetrics

An International Scientific Exhibition will be associated with the meetings of the Conference at Olympia, in which hospitals, research organizations, universities and the industry of the world will display their latest developments in the sphere of medical electronics.

During the Conference the delegates and their ladies will be able to take part in visits of scientific interest and in a number of social events which the Organizing Committee have arranged.

The President of the International Federation for Medical Electronics is Dr. V. K. Zworykin, well known to our members for his pioneering work on television pick-up tubes, electron multipliers and the like, who has repeatedly emphasized the importance to human life and health of the far-reaching advances which the Conference will record and publicize; the Chairman of the Organizing Committee is Dr. R. C. G. Williams, a Past-Chairman of the Electronics and Communications Section, who emphasizes also the magnitude of the contribution which a rapidly developing industry is making in this field, and urges members to assess its growing importance in their own life and work, and to make arrangements to attend the Conference.

Members who wish to do so should write at once to the Secretary of The Institution for a form of application.

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Physical models and psychological processes

The brain is an electrical system and can be investigated by means of electrical instruments. The electrical engineer therefore has a special interest in the exploratory work being done by neuro-physiologists. In this article Prof. Tustin reviews the psychological processes that are associated with the working of the human brain and discusses the relationship to these of recently developed pattern-recognizing mechanisms.

The article is based on his Chairman's Address to the Measurement and Control Section delivered at Savoy Place on the 13th October 1959. Prof. Tustin is Professor of Heavy Electrical Engineering, Imperial College of Science and Technology, University of London.

Prof. A. TUSTIN, M.SC., MEMBER

By delicate and intricate experiments neuro-physiologists are laying a foundation for an understanding of the working of the brain. Electrical engineers have a special interest in their work, for the brain is an electrical system and its investigation has been made possible by electrical instruments. Electrical engineers have also made or described devices, built from elements having the properties of nerve-cells, that produce behaviour analogous to the outcome of remembering, recognizing and learning. These achievements have made it possible to give a plausible account of the part played by the simpler animal brains in adapting behaviour to environmental circumstances.

Psychological processes in animals and man

In the higher animals and in man, behaviour is complex, and in man there is not only observation of behaviour but also some awareness of a sequence of thoughts and feelings that are associated both with stimuli and with behaviour.

The problem therefore arises of defining the essential functions that are associated with the working of the human brain, and of considering how these functions might be performed by mechanisms based on neurone-like elements. It is suggested later that a number of functions are distinguishable, besides those for which mechanisms have so far been proposed, for which an attempt to devise such mechanisms may not prove fruitless.

A first need is an analysis of psychological processes, but among psychologists there are differences of opinion about what essential functions may be distinguished. These largely arise from the extent to which attention is confined to behaviour as distinct from taking account also of our awareness of a sequence of thoughts and feelings, i.e. of 'introspection'.

Fifty years ago it would have seemed very odd to exclude introspection from the tools of psychology, but this has become an operative rule of the influential 'behaviourist' school of thought. The behaviourist point of view was originally a salutary and necessary discipline to avoid for example the possibility of a professor of psychology, when observing rats, interpreting their behaviour in terms of the thoughts and feelings of a professor of psychology. In animal psychology no other starting-point than behaviourism is generally valid, but in human psychology it is stultifying to neglect such clues as introspection may provide.

In order to see the relationship between physical models and psychological processes it is necessary to take note of the progressive elaboration of psychological processes from the simplest animals to man, and to attempt to discern new functions where they arise. Where in man account is taken of introspective clues, the results may be carried back to the animal world with the greatest caution.

Among precise observers of the behaviour of insects, fishes, birds and beasts have been many gifted writers, such as Fabre and Lorenz. Through the accounts of such observers, if not from common observation, most people are familiar with the fact that in much of the animal world behaviour is characterized by a certain rigidity. Some responses seem completely automatic, like the 'freezing' reflex of some birds when presented with a moving dark shape crudely resembling a hawk. These reflexes are rigid responses to limited stimulus-patterns and not responses to a total situation.

But, in spite of its basically reflex character, animal behaviour can be modified, and much of it has been shown to fall into the class that finds an adequate description in the concept of the conditioned reflex. A response that is initially caused by some stimulus can be triggered from some different stimulus if the latter has repeatedly been associated with the initial one. This is the most primitive form of learning, and it will be indicated later how all behaviour describable in this way can be related to hypothetical neurone-mechanisms.

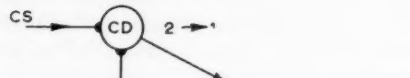
Latent learning

In the higher animals there are aspects of behaviour that cannot readily be described in terms of conditioned reflexes. For example, some learning is of the kind referred to as 'latent learning'. This does not result in any immediate response but may influence subsequent behaviour. Such learning may be a basis for primitive problem-solving, as when a dog is taken by a circuitous route to some distant place and takes a short-cut home.

It seems as if a systematic representation having

map-like properties is built up from various sensory clues. Some higher animals show the rudiments of intelligent behaviour, as when the apes studied by Köhler would spontaneously join two sticks together to reach a banana outside their cage.

Between man and the higher animals the difference in the degree of elaboration of the mechanisms that adapt behaviour to circumstances is very great, but in part the difference is a growth and refinement of types of adaptation that are discernible in the higher animals. Simple reflexes and conditioned reflexes are present in man, but he has also a remarkably developed capacity to build up a code-model or representation of the world about him, corresponding with his subjective experience of the



1 *Primitive scheme showing conditioning*

'awareness of reality'. Man has also developed conceptual speech, which is unknown in the rest of the animal world.

The processes in the human brain that may mediate between stimulus and behaviour are such that the response is but rarely determined by the immediate stimulus.

Consider for example a student about to finish his course, thinking about his future employment. There is no overt response; he is predicting (or imagining). His 'reality' is extending hypothetically to various futures. Momentarily he is in this or that factory or climbing the business ladder. But tentative prediction is not all that is going on. While he is a character in these imaginary dramas a motivational apparatus is also active. There is a play of desire or aversion, self-gratification, anxiety and so on, and at some stage there may be an outcome in resolution. Our student has a new complex purpose that may modify his behaviour from then on.

The elaboration in man of this representational exploration, which we refer to as thinking, has required a corresponding elaboration of his motivational mechanisms. Response to each of the succession of stimulus-patterns must be suspended until resolution is reached. One must pause to think, and the pause is a period of conflict of response-trends. We say of this peculiarity that we have 'free will'. Further, with increasing maturity, primary drives become structured, with suppression of some and dominance of others, in a most elaborate way, and we say of this characteristic that 'man is a moral creature'.

Psychological processes in man are thus extremely complex. We know that his brain is extremely complex in structure, and it is reasonable to ask whether there can be detected in it, or could conceivably exist in it, mechanisms of neurones (with possible chemical or other elements) the behaviour of which has some parallelism of form with these elaborate processes.

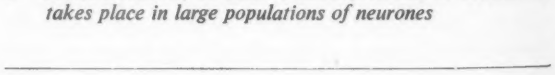
Present achievements in neurone-models

The first step must be to review what has so far been achieved. The possibility of mechanisms formed of nerve-cells that would produce reflex and conditioned-reflex behaviour has been a familiar idea from the close of the last century.

A model for 'learning' proposed in 1893 is shown in Fig. 1. Here the element CD (coincidence detector) is supposed to require at least two input pulses to cause it to discharge, but after a number of discharges it is supposed to become more sensitive, so that one input pulse suffices. Then if an 'unconditioned stimulus' US is accompanied on a number of occasions by a stimulus CS which is initially incapable of causing discharge, it will become capable of doing so because of this sensitization. But it is virtually certain that in the brain there is no use of single-neurone elements in this way.

A more up-to-date version of the same basic idea is shown in Fig. 2 (following Eccles). Here the nerve pathways shown are conceived to be pattern-transmitting channels, and the joint occurrence of stimulus patterns CS and US at a neural network CD would in due course sensitize a channel from CS to R.

Discriminating response to patterns of excitation is one of the primary functions that would be involved in any



2 *Eccles's scheme, in which sensitization due to coincidence takes place in large populations of neurones*

physical analogue of psychological processes. It arises when a distinctive response is made to an object seen or to a particular sound, and a similar function must surely play a part in motivational mechanisms.

There is great interest therefore in the recent construction of mechanisms using neurone-like elements that display conditioning or learning, as applied to distinguish patterns. These developments may not only contribute to the understanding of brain mechanisms, but they may lead to useful devices such as the machine-reading of print, or conceivably the 'automatic typist'.

Taylor's machine

Space will permit of a brief indication of the nature of only one of these devices. The one that is perhaps the most clearly suggestive of brain-like function is that described by W. K. Taylor (see March 1959 *Journal*, p. 157).

This machine, in its first sample form, showed rudimentary but remarkable properties of discriminating between patterns (such as the shapes of letters of the alphabet) and of being 'taught' to do so by 'showing' the pattern to the machine and pressing a button.

Fig. 3 indicates the essential elements of Taylor's machine. It is built from only two kinds of element, both of which were devised to simulate the properties of neurones or groups of neurones. The first type of element is constant in sensitivity and acts as a summator; the second has the property of increasing in sensitivity as signals are transmitted.

The operational steps of the machine are shown in Fig. 3, and essentially the several stages produce channel patterns different from, but characteristic of, the original retinal pattern. Stage one 'sharpens' the pattern by enhancing signals from edges and corners. Stage two is a crucial one. It can best be explained by supposing that each of its output channels were fed positively by some of its inputs and negatively from others, but with a different combination feeding each channel. Then the pattern produced could be said to represent the extent to which a particular pattern presented coincided with or resembled the various patterns of distribution of the connections.

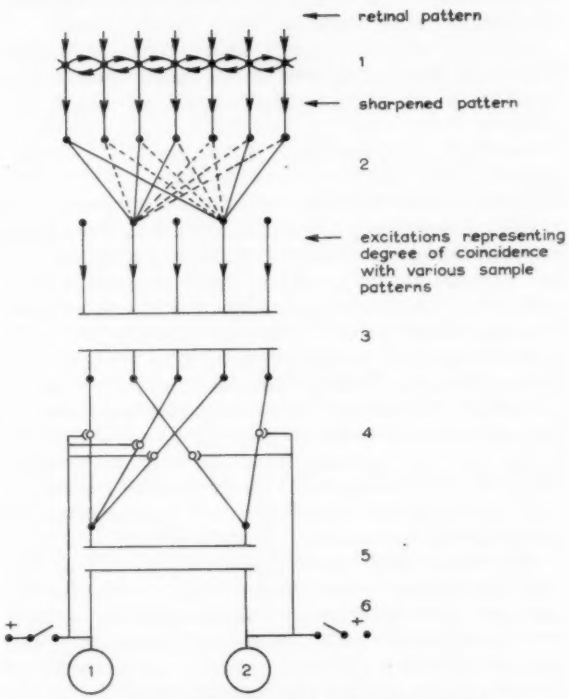
What is now required is to pick out the connections that have the strongest excitation, indicating the presence of pattern-elements. Stage three makes a step in this direction by eliminating those weaker signals arising from feebly represented patterns in favour of those more decisively present, which become dominant. It is a pattern-dominance element. The final stage is like stage two and discriminates these patterns again into the final classification.

Automatic self-sensitization

A 'pattern filter' as so far described would be difficult to construct because it could recognize some particular pattern or class of patterns only if it were specially wired up to do so. The essential step is now taken of introducing automatic self-sensitization by inserting units of the second type, with variable sensitivity, in the output lines from stage three. In Taylor's model these elements give an output (current) that, by closing a set of contacts by a pushbutton, may be made proportional not only to the input current but also to the integral of that current from the start of the operation.

Suppose that now the wiring is not prearranged to detect some predetermined patterns, but a particular pattern is presented to the retina element and then this sensitizing effect is brought into play in the lines feeding a selected output indicator. Then that particular pattern becomes associated with that particular output line, and if the same pattern is presented again it will always excite only that output line, so long as the extra sensitivity persists. The apparatus may thus be said to have been taught to recognize that pattern or class of patterns.

Such mechanisms are extremely close in function to those postulated in Eccles's scheme for conditioning. The pressing of the button is the unconditioned stimulus, the pattern the conditioned one.



3 *Main features of Taylor's pattern-learning machine*

1. Detail filter (edge intensifier)
2. Association units (combination detector)
3. Suppression of insignificant information (dominance unit)
4. Second combination detector with self-sensitization
5. Second dominance unit
6. Output (classification) connections activating self-sensitization

Space is too limited to give any account of several other important studies that have been made of possible mechanisms for pattern-learning, such as those of Uttley and O. G. Selfridge, or of possible mechanisms for the recognition of sounds such as have been described by Licklider.

Other psychological processes for which physical models may be sought

It has been suggested that besides pattern discrimination and learning there are other distinctive functions of the brain that invite attempts to create parallel

mechanisms of neurone-like elements. These include the building up of ordered representations from sensory clues, representational thinking and the structuring of motivations by resolution of conflict (i.e. by the dominance of some and the repression or suppression of others or by the discovery of patterns of response that satisfy several motives simultaneously). Very primitive and elemental devices do already exist that suggest that such functions are not outside the scope of mechanisms.

Automatic map-making is familiar in the route-mapper that can be fitted to automobiles to map a route from a wheel-revolution counter and a compass. But this is very primitive.

Elaborate representation

The representation of the environment that the brain of man builds up from sensory clues is immensely elaborate and has the property of being extended by the exploratory fringe corresponding to 'imagination' and representational thinking. Human thinking is of two distinct kinds. The process resulting in an answer to the classical question 'Will the sun rise tomorrow?' may be 'induction', as when the old lady remarked that if she got through to September she always lived the rest of the year. It may also be 'representational', as when we 'bring to mind' the rotating earth and the property of inertia and find no exploratory extension of our representation in which the sun fails to rise.

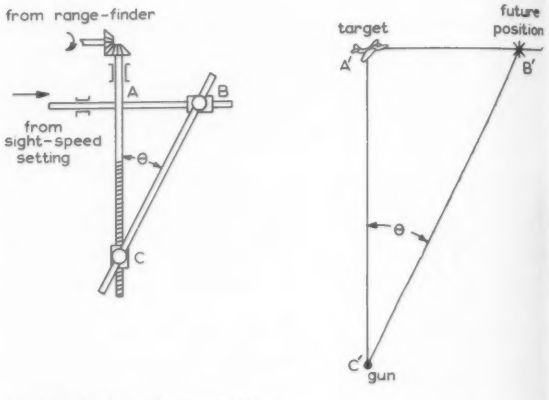
This latter kind of thinking corresponds to our map-like representation being more than a map, for it is extensible by a labile fringe like an animated cartoon. It is essentially not only a model but an analogue, and like the engineer's analogues it serves for prediction of events which it parallels and encodes.

Predictors

In this function the brain has been likened to the analogue predictors used in gunnery. Fig. 4 shows a very early form of predictor. Essentially it is an analogue. The internal triangle ABC is maintained in correspondence with the external triangle A′B′C′, whose corners are the gun, the target and the future target position, by the use of 'sensory clues' from the sight and the range-finder. This labile representation serves to control motor operations to bring about required results. It is noteworthy that in more modern predictors the 'model' is not spatial and visible. The relationships of triangularity are coded in forms such as vector relationships between magnetic fields in resolvers that are not so obvious.

Problems remaining

The success in pattern-handling and recognition makes it an inviting problem to consider whether assemblies of neurone-like elements can be devised that build up some systematic coded representation from sensory clues, this analogue having a labile extension or fringe having exploratory and predictive functions. The momentarily active parts of such a representation in process of modification or exploration would correspond with the field of attention or awareness. So far this task has not been attempted.



4 *Simplest analogue predictor*

An even more difficult task may be to investigate mechanisms corresponding to the ordering or patterning of motivations, but it may be significant that the notion of dominance and suppression has already appeared in the development of pattern-recognition.

There always remains the problem of the nature of consciousness. We do not know, nor is there at present any obvious way to discover, whether what we refer to as consciousness or awareness plays a causative part in the sequence from stimulus to behaviour, or whether it is to be regarded as a revealing accompaniment or aspect of physiological processes. This may become clearer if the remarkable progress already made in the development of physical models that simulate psychological processes can be advanced further. The possibilities of doing this are good enough to make their full exploration one of the most important of research enterprises in the immediate future.

Summary

The psychological processes in man include not only pattern-recognition and primitive learning but also thinking, imagining and purposing. The successful development of mechanisms using neurone-like elements that show behaviour simulating some psychological functions suggests that investigation should be directed to discovering possible neurone-mechanisms that would parallel these more complicated functions. It is suggested that one requirement is for something of the nature of an automatically constructed analogue, constituting a representation of the external world, built up under the control of sensory clues.

The Sixth Graham Clark Lecture

ENGINEERING AND CIVILIZATION

SIR HUGH BEAVER*, K.B.E., M.I.C.E., M.I.CHEM.E., M.E.I.C.

It was a happy memorial to Graham Clark to found this annual Lecture, and the broad approach to the engineers' world and problems that has developed in them would have appealed to him. I knew him—as many of you will have done—from his earliest days in The Institution of Civil Engineers. I collaborated closely with him more than 25 years ago in the exhibition by which that Institution marked the centenary of the death of Telford, their first President; and, as I inspected the stimulating exhibition with which three years ago the Institution celebrated the bicentenary of Telford's birth, I could not help thinking how much Graham Clark would have appreciated and approved.

It is too for me, and I am sure for all engineers who have given thought to these matters, refreshing and encouraging that the three great engineering institutions should have combined for this purpose of an annual consideration of some of the wider aspects of the picture before them. It shows their recognition of the immense front that engineering now presents, and the joint and heavy responsibilities that rest on all engineers alike and on all sections of engineering.

Specialization and fragmentation

This, as more than one of my predecessors has emphasized, has been an age of increasing and narrowing specialization. The number of existing engineering bodies in this country alone, is indeed staggering. Many years ago I remember attempting with my old chief Sir Alexander Gibb to work out something like a full list of them; and indeed he took it as the text of his Presidential Address to The Institution of Chemical Engineers in 1929. There were even then, he claimed, 'more than one hundred institutions, institutes, societies and associations devoted more or less directly to the science, subject and practice of engineering'. The number has in all probability greatly increased since then.

He went on, and I think it is worth following him, to consider some of the forms in which there had been some attempt to counter this dispersal and fragmentation—not indeed then, nor I think since, very effectively. He quoted the American Engineers Joint Council which had been founded in 1923 at the instigation of the mining engineer, Herbert Hoover, subsequently President of the United States—a purely technical and professional linking, with a similarly limited objective. He instanced the Engineering Foundation formed for the purpose of a joint approach to research by the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers and the United Engineering Society; and he quoted the interesting experiment started in Japan in 1919 by which the Presidents for the time being of the 12 major engineering institutions† formed a steering body to co-ordinate engineering policies and influence.

I do not know how far any of these have survived; their effectiveness has almost certainly never been very great, and the splintering of the engineering front goes on.

Only three years ago the then Director of the U.S. Atomic Energy Commission addressing the American Institute of Chemical Engineers deplored the fact that engineering had 'proliferated and fragmented to an untenable degree'. This he attributed to the inability of the established areas of engineering to accept the new demands that arose from new stages of development in engineering. All engineering bodies were, he thought, inclined as they grew older rather to narrow their outlook than to widen it; and this process was still going on. In fact in many ways it is inevitable.

In our own country too there have over the years been many and various efforts to minimize or counteract some of the effects of this fragmentation.

As long ago as the last year of the First World War there was formed, to assist the war effort, the Conjoint Board of Scientific Societies under the aegis of the Royal Society. By 1922 it was thought to have served its purpose and was brought to a close. I always regretted that this wartime collaboration had not been considered just as desirable in peace, but it was not. Quite recently there have been, to quote two instances, the British Conference on Automation and Computation, into which the engineering institutions have also brought the British Institute of Management; and the British Nuclear Energy Conference.

* Sir Hugh is managing director of Arthur Guinness, Son and Co. The Lecture was delivered at a Joint Meeting of The Institutions of Civil Engineers, of Mechanical Engineers, and of Electrical Engineers, at Savoy Place on the 3rd March 1960 (see p. 260).

† Including civil engineers (covering hydraulic, sewage, and mines engineering); mechanical (covering locomotive, automobile and aeronautical engineering); electrical; marine; chemical; metallurgical; heating and lighting; as well as architects!

How effective and how permanent in their influence these recent efforts may be we have yet to see.

A common purpose

It is not only in engineering that specialization and fragmentation are to be seen; it is probably a characteristic of all science. But it is by the nature of things most marked in engineering; and the result unfortunately must be to weaken, or misdirect, or conceal, that proper influence and the effective impact that engineering should—and should consciously—have on society and on civilization. For this is an age in which science and technology are inevitably having an ever-increasing effect on our lives as individuals, on this country's position and power, and on the whole world.

It is essential then that science and scientists and technologists should accept this and realize all that it means; it particularly falls to the engineer, the applier of science, to see himself as part of a service to his country and to mankind, and to condition his thinking accordingly. Thus it is that it is one of our greatest problems to see how, in spite of specialization in so many directions, we engineers may still recognize and have some common purpose and some ultimate worthwhile objective as being the real heart and final justification of all engineering effort.

It is in this context, and against this broad and perhaps ideal concept of all that engineering is and could be, that I approach this Lecture.

The greatest danger that we face in the world today is, I believe, that science and technology should not realize or should ignore what they owe to humanity; and that the arts, whatever that is taken to cover, should seek to or seem to maintain, wittingly or unwittingly, the wall that from time to time—but not always—has been erected round them. We cannot afford and we cannot risk this division between the so-called humanities on the one side and science on the other; and it is in my opinion wholly meaningless.

To say this is to say nothing new, to advance no strange doctrine. In theory at least all this is probably accepted by the majority of those who have given thought to it; indeed one can look back in history to periods not so far distant and to individuals at many different points in history that would never have imagined that there was here any proposition to dispute. To that I shall return later; but clearly meanwhile in practice today we have not found the solution; and I would quote Sir Eric Ashby* in his challenging description of the successful assault by technology on the academic strongholds, which ends thus:

'There is no great divergence between the attitude of the physicist toward the concept of entropy and the attitude of the philosopher toward the concept of virtue. But teaching and research in technology are unashamedly tendentious, and their tendentiousness has not been mellowed (as it has for medicine and law) by centuries of tradition. Technology is of the earth, earthy; it is susceptible to pressure from industry and government departments; it is under an obligation to deliver the goods. And so the *crude* engineer, the *mere* technologist (the very adjectives are symptoms of the attitude) are tolerated in universities because the State and industry are willing to finance them. Tolerated, but not assimilated; for the traditional don is not yet willing to admit that technologists may have anything intrinsic to contribute to academic life. It is not yet taken for granted that a faculty of technology enriches a university intellectually as well as materially. The attitude of universities toward technology is still ambiguous; until the ambiguity is resolved the universities will not have adapted themselves to one of the major consequences of the scientific revolution.'

* ASHBY, E.: 'Technology and the academics' (Macmillan, 1958)

The meaning of civilization

In all science there are, as I see it, two divisions of scientists for which it is I suppose the more easy than for any other division to recognize their direct responsibilities to their fellow-beings—I mean doctors and engineers; and so, believing that in this engineers are specially equipped to give a lead, I chose for my subject, engineering and civilization.

But what does one mean by civilization? This like so many words in English is bedevilled by various uses and misuses by different writers and speakers in differing contexts and at different times.

Toynbee in his massive 'Study of history' envisages countless 'societies' in the stages of man's history, spread over some *300000* years; some of which, having achieved a universal or semi-universal position, are treated by him as civilizations. He decides that there have been 19, or perhaps 21, of these civilizations, of which five still exist today, although the other four—at the moment at any rate—are completely overshadowed by our own, the Western civilization.

These various civilizations have risen and fallen, some linked perhaps tenuously and indirectly with an earlier or a later civilization, others like the Egyptian civilization without parent or child; and so some of them, and all the numerous 'societies' that never became civilizations, have perished and like the insubstantial pageant of our dreams left not a rack behind, disappearing without measured or recorded effect on their times or on later times, perhaps occasionally to be rediscovered as faint shadows like the earliest settlement of Jericho, recently unearthed nearly 10000 years old, a society without writing or history or name.

Are *we* then, like the near-men of the earliest eras—*Australopithecus* or Neanderthal man—to give way in our turn to others, having failed, as they did and the prehistoric animals, to find the means to hold our own against nature and to meet the demands of a changing world? That I may say is not my view.

You may, on the other hand, think that even those remote and shadowy civilizations and societies were, as now our own, just tides in the world's long history, always

even as they temporarily receded leaving the high-water mark a little further up the shore and leaving there too the accumulated flotsam of the endless ocean to be picked up in turn by the next high tide. *Or* you may feel that, whatever setbacks and difficulties there have been and will be, whatever bright flowerings and black eclipses, civilization is a continuous motion steadily and relentlessly pressing forward all the time. *That* is the sense in which I use the word civilization.

If, as I hope, this is your view too, then you must today feel yourselves more than ever concerned—concerned both at the immensity of the problem before us and at the speed with which we seem to be moving. But *in any case*, and however you may decide, one must march forward whatever the past, whatever the future; and this applies particularly as I believe to the engineer and to the great engineering institutions.

The Lectures as chapters

Many of you may have heard all the five previous Graham Clark Lectures at the time; or have read them subsequently. But perhaps not many of you have read them as a whole, as I have recently done and as I would recommend to you. They were:

The First	Sir Harold Hartley on 'The engineer's contribution to the conservation of natural resources'
The Second	Sir Maurice Bowra on 'The impact of engineering on society'
The Third	Sir Ifor Evans on 'The place of engineering in university education'
The Fourth	Sir Ewart Smith on 'The engineer and management'
The Fifth	Sir Arnold Plant on 'Engineering in an expanding economy'

I shall refer to some of them in more detail later, but I have given you the titles because I want you to see them as part of a single picture that is still being painted, for which you have called on minds from other disciplines than engineering to contribute; indeed only one of the five Lectures was delivered by an engineer in the strict sense. Intentionally or unintentionally you have moved from what was perhaps the original purpose; and in this you have been completely right.

The note that I have of the origin of these Lectures states laconically that Graham Clark had suggested that 'an annual lecture should be given on a subject of common interest to the members of The Institution of Civil Engineers, The Institution of Mechanical Engineers and The Institution of Electrical Engineers'; and after his death the idea was taken up and the Lecture named after him. But in the event the approach has been on a much broader front, a front that must concern and interest a much larger body of engineering thought than even the combined membership of your three great institutions.

These five Lectures are indeed between them already a real contribution to engineering thinking—towards the formulation in our minds of what our own long-term philosophy should be—for the better information of our colleagues and companions in the service of man—towards the influencing of education in technology and science—and finally I would hope to the moulding of public opinion.

As I went through them I was convinced that we shall get the most out of these Lectures—out of the whole idea of the Graham Clark Lectures—if we make some sort of effort to see each Lecture as a chapter as it were in a purposeful and coherent book—rather than an anthology of brilliant ephemeral essays. At least that is how I have seen it, and to that end I want to attempt to associate with my views those of my predecessors—either positively or it may be in some cases negatively and by disagreement.

I do not know whether I shall be successful; and it may be presumptuous of me to think that I can throw any new light or carry forward these considerations a further stage. But I want to try to see where the effort leads us and what action should or could follow; for this question, namely what is the engineers' role to be in the intensely interesting and difficult future that certainly lies before us, must be of predominant importance to us—disturbing and alluring at the same time. So much we have done to make the world what it is, so much we must do to improve and indeed to save it.

A crisis of history

My object then is to try to put into perspective these Lectures in the wide field of engineering thought and achievement and attempt; and from this to encourage you to project your own minds forward to envisaging the duty of the engineer in the new world and the future that is so rapidly developing in front of us. I must at the outset reiterate my conviction—and I am sure it is yours also—that these are momentous times. It is worth pausing to think of some of the new factors other than technological that are compelling this.

In the first place of importance, I think, is the fact that the population of the world is advancing at what by any calculation is a staggering rate. It is now not very much short of 3000 million, and at the present rate of increase will or could be 4000 million in some 20 or 25 years' time and 5500 million by the end of the century, in the lifetime of many here tonight. At the same time we see new civilizations such as that of Russia or old civilizations like China and Asia pushing into the forefront and obviously going to take a dominant place in the picture; and tomorrow there will be Africa.

We, the nations of Europe and North America, moreover, are now faced with the tremendous problem of the so-called underdeveloped countries—ceaselessly claiming our attention, our service, and our money and at the same time adamantly asserting their own authority and independence. It is obvious that the speed of advance which all these emerging countries envisage would more than tax all world resources however mobilized; their

hopes are not in any way to be achieved by all the available money, however well used. And although I do not accept the view that the gulf between the 'haves' and the 'have nots' is widening as is so often said, yet certainly the recognition of this gulf grows keener every day.

To add to all this, science and technology have brought us to the very edge of potential world destruction; while scientific research has brought us perhaps just to the threshold of the secret of the artificial, the synthetic creation of living organisms.

There is then full reason for those who fear that the world approaches its grand climacteric. But be that as it may, it is certain that our own country and our Western world are at a critical point in history—whether the next stage is our further advance or the overwhelming of our civilization, using the word in Prof. Toynbee's sense. This is the situation, which engineers have done so much to create, and in which they now find themselves faced with the problem whether they can save it.

The special responsibility of engineers

It would be unrealistic to discuss the long-term world duties of engineers, and for this country to forget its own position and to ignore the immediate, if mundane, question whether we in Great Britain have enough engineers; and vitally important too for us are the problems of the means of production of engineers, their education and their training—not only from the technological point of view, for even more profound and much more difficult is the question how we are to produce not only engineers but civilizers.

In this I do not want to stop at the physical standards of civilized life; but it is through this materialistic approach that one must in the end come to consider what I shall call the philosophical side. I am thus not so much thinking of the engineers' contribution to the doubling of our standards of living in this country in the next 25 years; nor of the engineers' part in the claim—for what it is worth—that today 'we have never had it so good'. But it *is* the basis of my case that engineers have a special long-term responsibility because it is they who have built this modern world of convenience and comfort; and who all through the ages have not only been improving conditions of life but have also produced all the means and machines of destruction.

Sir Harold Hartley reviewed very ably but necessarily incompletely the part that engineering has played—even if not always itself recognizing its own great part or always being duly credited by the world at large—in the development of natural resources, in the provision of facilities and amenities, in the softening of the rigours of life which are the marks through the ages of developing civilization—the growth of living standards. I will not go over the details; they are known to you, at least in the broad picture—from the wheel and the remarkable irrigation systems of say 5000 years ago to the space vessel of tomorrow. All this has in its fruition and development been the work of engineers applying the discoveries of science.

Some who have discussed these questions have I know looked on engineering as just a development from the crafts, and have said that only in the last two or three hundred years has there really been any science to apply. Others have looked on engineering as essentially being the ability to get machines and instruments to do the job of manual workers, and so have considered that engineering is only the product of recent centuries when shortage of labour began to be the ruling factor; they would I suppose say that, because there were expendable thousands to build the Pyramids by manpower, those who constructed them were not engineers and that that was not an age of engineering.

I do not think either view is tenable. It is in my opinion both incorrect and dangerously misleading to think that the basis of developed engineering ever was or is shortage of manpower. In fact today we in this country are, in a way, proving, or perhaps trying to prove, the very opposite—that manpower is the basis of engineering and not the shortage of manpower. For in this most highly developed age of engineering, with a far larger proportion of our people engaged industrially, and therefore in engineering, than in any other country, and with all the inventions and labour-saving devices in use or foreshadowed, it is likely that we in these islands may eventually find ourselves outdistanced by our competitors simply because of their greater sources of manpower—and for no other reason.

As Sir Maurice Bowra has said, we must certainly admit that, without engineering, civilization is impossible; and even though, as he thought, it was not always of first importance, yet without engineering a civilization is doomed. China and Greece and Rome in turn, as he sees them, paid the price for treating engineering as of secondary importance and lost their leadership in the world of their days.

The riddle of the Sphinx

I don't think that anyone questions that engineering has continuously throughout history improved the standards and conditions of living, until now we have reached the present position when, to quote Sir Ewart Smith, 'the advance of science and its practical application through engineering and chemical technology has shown that mankind has the potential ability to achieve any standard of material well-being that may be desired'. That is a great claim on behalf of engineering.

What more then is it that we require from engineering? 'Where', answers Sir Maurice Bowra, 'the engineers have gone wrong is . . . that they have set out to improve the human lot—and have assumed that this just means the greater exploitation of natural resources for the benefit of humanity.' And more positively Sir Ewart Smith again adds—but speaking in the rather narrow context of management—'our own civilization can continue successfully only if it achieves *a balanced combination* of the

humanities and technology, based on both science and art'.

This is no new criticism or suggestion: it is one continually being made in these days; although if you go far enough back you will not find it being made, because there was then no need to do so. It is the result of our age of specialization that I now have to make the point. To Leonardo da Vinci and to those who flamed in the sky of the wonderful Renaissance, in our own Elizabethan age and indeed even later when the Royal Society was born, there was not this distinction between culture and art and science and engineering.

And it is worth recalling that—as Smiles pointed out with a good deal of truth—the fathers of engineering, as we now know it in this country, were a curiously mixed lot in their origin—Bridgewater the eccentric aristocrat, Myddleton a London goldsmith, Brindley a wheelwright, Smeaton an attorney's clerk, Rennie a millwright, Telford a mason, Stephenson an engine brakesman, all of them drawn to the exciting adventure of practical and creative engineering. It was *then* an adventure open to all—an adventure worth while in itself, where few if any paused to think where it was all leading. We cannot take that easy line now.

But I think it is not inappropriate here to recall to you Bacon's pleasing use of the Sphinx's riddle in that series of mythological fables that he called the Wisdom of the Ancients. He so named them because, as he wrote, 'upon deliberate consideration my judgement is that a concealed instruction and allegory were originally intended in many of the ancient fables'. 'This riddle of the Sphinx', he then proceeds, 'is an elegant, instructive fable, and seems invented to represent science, especially as joined with practice. For science may without absurdity be called a monster; her figure and form is varied by reason of the vast variety of subjects that science considers; her voice and countenance are represented as female by reason of her gay appearance and volubility of speech. . . .' 'Sphinx is said to propose various difficult questions and riddles to men which are harmless and entertaining for contemplation and enquiry so long as there is no other end but knowledge. But which as soon as they are put into practice, which urges and impels to action, choice and determination, then it is that they become torturing, severe and trying and unless solved and interpreted strangely perplex and harass the human mind, rend it in every way and perfectly tear it to pieces. All the riddles of the Sphinx therefore have two conditions annexed, viz. dilaceration to those who do not solve them, and empire to those that do . . . Sphinx has no more than two kinds of riddle, one relating to the nature of things, the other to the nature of man—and the prizes are two kinds of empire—the empire over nature and the empire over man.'

Is not this just what faces us today? May not this perplexing, harassing problem perhaps really be part, or all, of the explanation of some who have not been able to distinguish between their duty to their country and their duty, as they have seen it,—a perverted view no doubt—to mankind. Such thoughts undoubtedly swayed some at any rate of the nuclear traitors—the Nunn Mays and Fuchses and Pontecorvos of our country. Some such dilemma, real or false, perplexes at least some of those who march to Aldermaston or camp outside aerodromes to show their disapproval of the H bomb.

These are problems that as Bacon says mean dilaceration to those who do not solve them; and they are not the physical and chemical problems which in the end will always be solved but the problems that follow thereon in regard to their impact on mankind, which unless we solve, we must face the extinction of civilization and perhaps of mankind. That is the problem of all, but particularly of scientists and technologists and engineers.

Definitions

I have used the words scientists and technologists and engineers and I must endeavour to explain what I mean. I confess that I often find myself puzzled and confused by the meanings that seem to be intended by various people using the words scientist, engineer, technologist, technician.

The Ministry of Labour's definition of scientists in the several surveys that have been made by that Ministry of our scientific manpower is simply that 'a *scientist* means a university graduate whether in biology; chemistry; geology; mathematics; physics or general science'. That leaves wide open the all-important question of whether we are talking of the pure scientist, or the experimental scientist, or the applied scientist or of all three.

The definitions of technologist and technician in the 1956 White Paper on Technical Education* similarly do not help very much—and do not I think really hold water. 'A *technologist*', it says, 'has the qualifications and experience required for membership of a professional institution. Most university graduates in engineering and other applied sciences, and a good proportion of holders of Higher National Diplomas or Certificates or similar qualifications, become technologists. A technologist has studied the *fundamental principles* of his chosen technology and should be able to use his knowledge and experience to initiate practical developments. He is expected to accept a high degree of responsibility and in many cases [so the definition says] *to push forward the boundaries of knowledge* in his own particular field.'

And a *technician* on the other hand is described as 'qualified by specialist technical education and practical training to work under the general direction of a technologist. Consequently—I like the consequently—he will require a *good* knowledge of mathematics and science [again I quote] related to his own speciality. Examples of technicians in the factory are assistant designers and junior ranks of management on the shop floor.'

And, to complete the confusion, the engineer is just described as 'a university graduate with a degree or one having other professional qualification, in chemical engineering, civil and structural engineering, mining

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engineering, mechanical engineering, aeronautical engineering and metallurgy'. Well, there you are.

I could quote—and you could quote—many more definitions, and perhaps even more confused and confusing uses, of these terms. I do not myself think that one can in fact draw sharp dividing lines of definition that apply uniformly in all conditions whether during the educational period or in the subsequent working years. But in using these broad terms we all, I believe, know broadly what we mean.

A large number of chemists and physicists will in due course be engaged in the application of the discoveries of science and not directly in research and the pushing out of the boundaries of scientific knowledge; and all application of science involves engineering and technology. The great bulk of engineers who come through the universities, and all who 'come up the hard way', will be employed in the application of the discoveries of scientific research, but some few will become involved in research.

All I would say for the purpose of this study and for the purpose of measuring our 'scientific manpower' is that I think one must take science and technology, or the scientist and the engineer, as composite terms—without either attempting to make a hard and fast definition, because such will never hold water, or to determine the proper proportions of technologists or engineers to scientists, because these will vary immensely in different fields and at different times.

Education in an age of technology

In this wide sense let us see how we stand in regard to numbers—in regard to which Prof. Jewkes in his Presidential Address to the Economics Section of the British Association meeting at York in 1959 has said that we are overstating our needs.

The latest report of the Committee on Scientific and Engineering Manpower in Great Britain (November 1959)* shows that in fact there is still a seriously inadequate supply of scientists and engineers; that the actual number of immediate vacancies in industry was in January 1959 nearly 6000; and that the shortage of engineers, particularly civil and electrical engineers, is greater than the shortage of scientists. And incidentally, of even greater ultimate effect I believe is the fact that neither industry nor the scientific professions have yet seriously faced the problem of bringing in the immense—almost untapped—source of womanpower to help to fill the void and to strengthen our position against future demands. But that I must leave.

Whether one measures our need by comparison with the actual number operating in countries that are proving themselves so competitive with us; or by the immediate demands of our own industries, as well as for administrative and teaching posts; or by the more elusive criterion of what we *ought* to need, there *is* now a shortage. This—if it is to be met—will mean the switching to science and still more to engineering of many who would otherwise have gone into other activities and fields of learning. That is indeed happening now.

The question then that again faces us here is not what are the proper proportions of our manpower to be directed or attracted to this discipline or that; but how we are best to educate this and future generations in which inevitably the preponderance of the educated output must for ever be scientific and engineering.

I accept the terms, arts and the humanities, as describing a side of life which has in the past been often and insistently distinct from science or the applications of science, that is to say, engineering. I do not consider that can be accepted today. We obviously cannot now—even if we ever could have done so—safely leave it to the humanist, the non-scientist, to readjust the balance of things whenever the application of science puts the boat out of trim. But how *do* we achieve that 'balanced combination of the humanities with technology' of which Sir Ewart Smith speaks? That is a vital problem. Many educationists have expressed their views, and some tentative but interesting experiments are being made. I will quote only two.

Readjusting the balance

In a paper which Prof. Baker, the Head of the Engineering Department at Cambridge, read some three years ago at the Summer Meeting of The Institution of Mechanical Engineers, he ended as follows:

'Turning towards the future, there will be further developments in our treatment of the physical sciences and their application, but first we are likely to see growth in studies related to management. Technical engineering takes place in the social and economic environment of industry, and it seems to us desirable to introduce students to the growing body of knowledge concerned with this environment. Many places have experimented with courses of arts lectures designed to help the technologists towards a fuller and richer preparation for life. We do not consider this "top dressing" [his words not mine] necessary here in a residential university, but we have, for many years, included courses of lectures on management problems, industrial psychology, and industrial relations.' 'There is, too,' he goes on, 'room for a new Group in the Part II Tripos Course, so that men could spend a year on the study of human relations and other management topics rather than on the physical subjects offered by the other Groups. There also seems no reason why, if extended successfully into other management fields, a third postgraduate course of instruction should not be instituted in the more distant future.'

In the Report of January 1959 to the University of Cambridge by the Faculty Board of Engineering, there occurs this:

'Since the beginning of 1957 the Board have caused a study to be made of management education in the United

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States of America and elsewhere, and they have sought advice from members of other Faculties in the University, from industry, and from other interested bodies. As a consequence of this study, and from the experience gained in the Department of Engineering from teaching management subjects for the Examination in Engineering Studies, the Board are satisfied that there is a sufficient body of knowledge and that teaching can be of a sufficiently high standard to justify the introduction of teaching in management at a standard comparable to a Tripos.'

And as you probably know there has now been introduced at Cambridge a one-year course for an examination in the principles of industrial management in which for instance there will be papers, *inter alia*, on human behaviour in industry and on the social environment of industry.

The other case I would quote is the joint action for some years past of the Imperial College (of Science and Technology) and the London School of Economics (and Political Science) to provide a scheme of joint graduate and postgraduate studies in technology, economics and administration. The course of economics for engineers and applied scientists is intended to provide an introductory knowledge of economics in relation to industry and business organization for university students who have completed or are completing their first-degree work; and with the course there are, as one of its most valuable sides, a series of evening seminars at which some or other prominent industrialist meets the students.

Invert the whole edifice

Both these approaches, i.e. the Cambridge and the London, are experimental and they are largely influenced by and aimed at the problem of industrial management. They may in time give birth to a full course in management, in exactly the same way that engineering in the United States was the mother of management as a university subject and discipline. But it must inevitably be questioned whether any of these approaches go far enough. Certainly they go very little of the distance to the goal that I have in mind where science and its application are themselves the basis and means of a humanistic education, the new civilization. The recent Crowther Report too deals at length with these problems of the production of men and women who can comprehend the impact of science upon society, and the 'corollary that scientists and technicians should be exposed to the radiation of humane letters'.

But as long ago as 1867–68, in giving evidence to the Parliamentary Select Committee on Scientific Instruction, Huxley challenged the whole concept of university education as it then was. 'The universities', he said, 'make literature and grammar the basis of education; they actually plume themselves upon the outside of the fabric.' 'Now that in my apprehension', he went on, 'is not real culture, nor is it what I understand by a liberal education. The thing you really have to do is, in my opinion, to invert the whole edifice and to make the foundation science, and literature the superstructure and final covering'!

We might dismiss all this—as no doubt it was then dismissed—as the costive words of an irritable and critical individual; but quite recently Sir Eric Ashby in the lectures to which I have already referred has returned to the charge in very similar though not such provocative words. He quotes from Whitehead's 'Science and the modern world' published in 1927 as follows:

'There is something between the gross specialized values of the mere practical man and the thin specialized values of the mere scholar. Both types have missed something; and if you add together the two sets of values, you do not obtain the missing elements. When you understand all about the sun and all about the atmosphere and all about the rotation of the earth, you may still miss the radiance of the sunset. There is no substitute for the direct perception of the concrete achievement of a thing in its actuality. . . . A factory with its machinery, its community of operatives, its social services to the general population, its dependence upon organizing and designing genius, its potentialities as a source of wealth to the holders of its stock is an organism exhibiting a variety of vivid values. What we want to train is the habit of apprehending such an organism in its completeness.'

And then Sir Eric proceeds to comment as follows:

'The habit of apprehending a technology in its completeness; this is the essence of technological humanism, and this is what we should expect education in higher technology to achieve. I believe it could be achieved by making specialist studies (whatever they are: metallurgy, or dentistry or Norse philology) the core around which are grouped liberal studies which are relevant to these specialist studies. But they must be relevant: the path to culture should be through a man's specialism not by-passing it.'

No room

Well that is brave thinking (although I am not sure that Huxley is not nearing the truth); and unfortunately, as Sir Eric Ashby recognizes and as all others who have studied this problem have realized, anything like this would require at least another year at a university. The Rector of the Imperial College of Science and Technology, Sir Patrick Linstead, in his Hinchley Memorial Lecture to The Institution of Chemical Engineers in 1957 took the same subject, 'Education for our times'. 'Should scientists and engineers be taught non-scientific subjects at the university?', he asked, and went on 'This last question goes very deep. The particular question which I should like to ask is how far we can help students of science and technology to acquire a broader education and the attributes of leadership during their university career. This is not a problem for the university alone. It is a general human problem. . . . Neither is this a problem peculiar to scientists and engineers. Many scientists are

certainly narrow specialists, but for complacent ignorance of vast tracts of human knowledge they cannot claim to excel many of their arts colleagues.'

'Let us however', he says, 'return to the immediate question, which is what can the universities do for their students of science and engineering.' In the first place, Sir Patrick Linstead considers the proposition that time should be found for the liberalizing process by extending the length of the bachelor course both in science and engineering to four years, which would put us nearer the position in almost all other countries in the world. This, entailing as it must an immediate capital expenditure of perhaps £20 million and a hiatus in output of upwards of 7000 graduates for one year, would he finds be quite impossible in relation to the country's urgent needs.

He concludes eventually that there is no room for the introduction of compulsory and examinable non-scientific subjects into a three-year first-degree science or technological course and that all that a university or a college can do is to make a continuous and organized effort to provide facilities whereby a student can broaden his outlook, interests and experience. There could in addition he thinks be certain types of non-scientific study which arise directly and as it were functionally out of a man's vocational interests which could be properly studied as part of them, or side by side with them. He instances the learning of Russian or of economics or of the history of science and technology.

Establishing the ends

That may not seem to go very far. But you will see how much thought is being given by many educationists to the problem of producing the adequate citizen for the new world, for furnishing citizens who can deal with the problems of a scientific world whether they approach them from the side of arts and the humanities or from the side of science and engineering; and in particular to produce the scientist and the engineer as full educated citizens of their country and of the world.

But how much thought is being given to it by engineers themselves? The engineer is responsible for all the physical basis and development of civilization; it is he who sooner or later translates into action every discovery of science; he lives much closer to life as it is lived by the ordinary man than does the scientific researcher. Here then are both his responsibility and his opportunity.

Here too we have another aspect to be considered. Engineering has never, as Sir Maurice Bowra sees it, been revolutionary in the political sense. 'If we regard politics as the struggle for power, engineering is', he says, 'not a political activity.' I think it would be difficult to be quite certain that this has always been so; but by and large I believe we must accept the charge. But no one has the right to disclaim or 'opt out' of politics, least of all the engineer. The Greeks had for such a one—as for other types—a name. They called the citizen who took no active interest in politics—a private person—an ἰδιώτης. Hence our word idiot!

Is this then not something to which the great institutions should give continuous—and not just occasional—thought? They have in their combined membership a great body of practical people. They can have profound effect on education. Moreover, education goes on all through one's working life, and if it seems difficult—although I personally do not accept this—to see how schools and universities can at the same time produce in the same person both the scientist and technologist and the man of wide vision, then is it not possible for the institutions to see how far they can in part at least rectify this omission in the post-university life—in the working life; looking on themselves not solely as platforms for technical discussion but as providing the means of studying how there can be greater contribution by engineers of the future to the civilization of the future?

If I may make one final quotation—from the Second Graham Clark Lecture, Sir Maurice Bowra's—it is this:

'As the Greeks said "even the gods do not fight against necessity", and for us engineering has become a necessity. It has brought untold benefits to the world, and if it has often enough been held responsible for our catastrophes, it is we, and not it, who are to blame. I even cherish the hope that it may help to solve some of our political troubles. . . . Man's unique position in the scheme of things lies in his ability to turn nature to his own ends, and if he really knows what these ends are, he should be able to do on an ever extended scale what he has already begun to do with such imagination and devotion and skill.'

That is a testimony to what engineers have done, but it is even more a warning of what they have to do; and that will not be achieved by one Graham Clark Lecture a year. We have much more to do.

I do seriously suggest to you that it is not enough to devote just one hour out of the year—0·01% if my arithmetic is correct—to considering in this way 'a subject of common interest to the three institutions'. And I suggest too that as time goes on the vitality of these Lectures—if just left by themselves—may die out, and this piece of collaboration follow the pattern of so many attempts at joint effort in the past. Would you not rather consider the Graham Clark Lectures as just the prelude to ring up the curtain on something much more concrete, much more ambitious and much more dynamic on your part—to make your joint effective and continuing contribution to this urgent problem of the Engineer and Civilization?

Research Reactors Division

THE new Research Reactors Division of the United Kingdom Atomic Energy Authority at Harwell will be responsible for the operation, maintenance, safety and development of Harwell research reactors and their facilities, including rigs, loops and auxiliary equipment. It will also undertake physics experiments to solve design and operational problems and studies on possible future research-reactor systems.

621.311.23

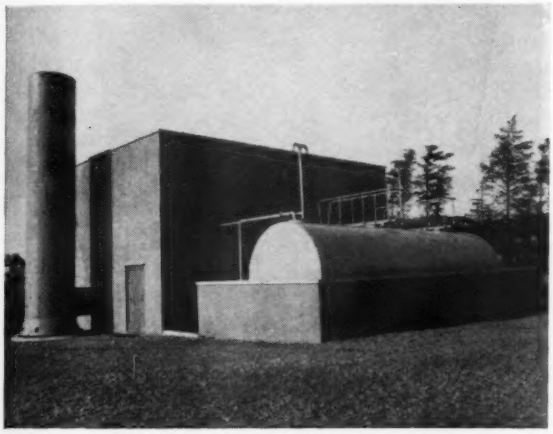
3 MW GAS-TURBINE GENERATORS

A small emergency generating station, equipped with a 4250 h.p. internal-combustion engine and controlled by telephone from a room 100 miles away, went into service at Princetown, Devon, in December 1959. The economic advantages of such small sets and their future, particularly in remote parts of the West Country, are outlined in this note by Mr. Irens, who is Chairman of the South Western Electricity Board.

A. N. IRENS, MEMBER

THE provision of a number of small automatic standby generating stations would seem an economical way of improving the reliability of electricity supply. These low-cost sets have two special advantages: capital investment on duplicate lines can be postponed, and generating capacity can be provided in short-time peak conditions at a low cost.

The first consideration applies particularly to rural areas with an inherently low 'load density' and where the rate of growth of load is small in relation to the cost of system reinforcement occasioned by the length of duplicate lines required for a firm supply. (In many remote parts of the West Country, supply is dependent on a single line.)



1 *The unmanned power station at Princetown, Devon*
Within 2½ min the station is stepped up to full output at 11 kV

For example it is not uncommon to find that a rate of growth of a megawatt or less per annum at a given rural load centre can reach a stage where the provision of a duplicate 33 kV line is called for in order to give a firm supply at reasonable voltage in fault conditions. The cost can be a good deal more than that of one of these small generating stations, even allowing for the expense of moving the set to a new site if necessary after a few years' operation.

The ultimate peak load on any system for public supply may last for only a few hours in a year and the cost of providing for this short-time peak, even with plant on which the capital has been written off, can be quite high. With conventional plant it is of course necessary to have the generators for peak operation running in anticipation of the load because of the time taken in starting; this costs money in wages, fuel and maintenance.

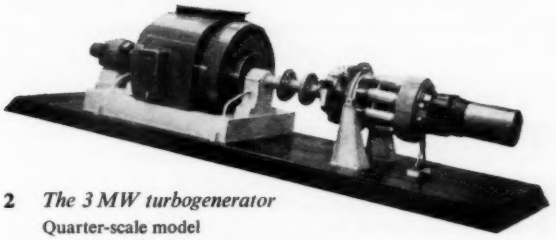
Ideal peak-load plant

The ideal peak-load generating plant should have the following characteristics:

Low over-all capital cost
Absolute reliability
Automatic starting and running under remote control
The acceptance of full load in the shortest possible time from initiation of starting.

To meet these requirements it seems logical to use as a prime mover a fully developed aircraft-type gas turbine; this in fact is what has been done for the installation at Princetown (Fig. 1) and is in hand for Lynton (Devon).

A Proteus 'two-spool' 4250 h.p. gas turbine has been coupled to an air-cooled 11 kV alternator (Fig. 2), and apart from the remote-control equipment the whole plant is relatively simple and utilizes standard components of proved reliability.



2 *The 3 MW turbogenerator*
Quarter-scale model

Reliability is expected to be high, as the engine has been thoroughly proved in the Britannia aircraft and is certified for 2000 hours' operation between overhauls.

Started by telephone call

Automatic starting and running are carried out by supervisory equipment (Fig. 3) connected with a control room at Bristol by a normal trunk telephone call as required, the line being cleared after any operations have been completed. If there is a change in conditions at the

generating station, a trunk call is automatically put through to Bristol and the information is shown on the display panel.

Owing to the low mass and the largely radial distribution of thermal stresses the set can be started, synchronized and put on full load in about 2 min, and this can be done frequently—throughout the day if necessary—without any harm being done.

The first station at Princetown was commissioned in December 1959 and the operating experience to date has been entirely satisfactory, with practically no 'teething troubles'. With low ambient temperatures which coincide with peak demands the output is found to be 3200 kW.

No cooling water is required nor are there heavy foundations, and the total cost for the complete installation including all building works was £74 655, i.e. just over £23 per kilowatt sent out.

Successful start

Up to the 20th January 1960 the set had run for 100 hours (including commissioning) and had started successfully every time on about 50 occasions.

The fuel consumption is 0·82 lb/kWh, giving a running cost of 1·3d. per kWh. This is relatively high, but as the set will normally run for less then 100 hours per year it is of small consequence. It is a matter of interest that the lubricating-oil consumption is negligible.

There was some doubt whether the noise level would be acceptable, but in practice the measures taken to silence the intake and exhaust have been most effective and no complaint could arise even in a built-up area.

The concept of several such unattended power stations at strategic terminal points of the supply network is of interest as being complementary to large highly efficient power stations sited with regard to fuel availability.

Furthermore, there may be a case for running the generator as a synchronous condenser to compensate the reactive component in long transmission lines; for this duty a clutch would be fitted between the engine and generator.

3 *Control panel for the Princetown generator at the South Western Electricity Board's new control centre at Bristol*

PROPOSED SITES FOR NEW COAL-FIRED POWER STATIONS

THE Central Electricity Generating Board have selected two sites in Nottinghamshire suitable for the construction of large coal-fired power stations. One is at Holme Pierrepont, 2 miles SE. of Nottingham, and the other at West Burton, 2 miles SW. of Gainsborough.

Each is considered suitable for a station of about 2000 MW capacity, burning 5 million tons of coal a year; and there is the possibility of further development. If authorized the stations will incorporate the large boiler and turbine units that have become a feature of the Board's recent schemes.

The search for sites has been concentrated near the Nottinghamshire and North Derbyshire coalfield, which is the largest producer of coal for electricity generation. Mining here is extensively mechanized and a number of new sinkings and major reconstruction schemes are in hand. In consequence the productivity of this coalfield, already well above the national average, is expected to rise still further. Output will rise too, particularly of the small coal that can be burned efficiently by power stations.

Both sites will be accessible by rail: the West Burton one adjoins an existing railway line, while the Holme Pierrepont site can make use of a spur now being constructed for the new Cotgrave colliery. They are also close to the river Trent, which is the only adequate source of cooling-tower make-up water for large power stations in the East Midlands.

The Board's investigations in the area have revealed sites suitable for later power stations at Cottam and Ratcliffe-on-Soar, and one at Market Warsop that will become a possibility if the dry cooling tower proves a commercial proposition.

Coal-fired power stations already working or planned in the East Midlands include Drakelow A, B and C (2220 MW); Willington A and B (800 MW); Castle Donington (600 MW); Staythorpe A and B (720 MW); and High Marnham (1000 MW).

The operations of the World Bank

Mr. Squire devotes the opening section of this article to a description of the World Bank and its global lending programme. Thereafter he outlines the procedures followed in processing loan applications so as to ensure to the maximum degree the efficient use of the loan funds by the Bank's borrowers in the less-developed countries of the world.

The article is based on an extract from the 1959 Annual Lecture to the Supply Section of The Institution, and a report of the meeting at Savoy Place on the 20th May 1959 at which it was delivered appears on p. 617 of the October 1959 Journal. The author is Assistant Director, Technical Operations Department of the World Bank.

P. J. SQUIRE, B.SC.(ENG.), MEMBER

BOTH the International Monetary Fund and the International Bank for Reconstruction and Development were conceived at the Economic Conference which took place in 1944 at Bretton Woods in New Hampshire. These twins, which both have the status of Special Agencies of the United Nations, have the same member-countries but play quite different roles.

The Fund's purpose is to provide assistance to enable member-countries to overcome short-term difficulties which threaten the stability of their currencies. This assistance includes short-term loans and advice on exchange and monetary policies; and a willingness on the part of the would-be borrower to institute measures calculated to restore stability is a prerequisite of help from the Fund.

The World Bank, on the other hand, makes medium- and long-term loans in the member-countries, with the guarantee of the governments concerned, to assist in their economic development. As one sees from the Bank's formal name, it was also charged with the task of assisting post-war reconstruction, and indeed at the beginning of its operations, which started in 1946, the Bank made loans for this purpose to France, the Netherlands, Denmark and Luxembourg amounting in total to nearly $500 million. The task of financing post-war reconstruction in Europe was soon taken over by the Marshall Plan, and since 1948 our loans have been made entirely for economic development.

The Bretton Woods Conference was attended by 44 nations, and all but three of these (the Soviet Union, New Zealand and Liberia) subsequently joined the two institutions. Since that time, nearly all other countries of any economic importance outside the Soviet bloc (except Switzerland, Portugal and New Zealand) have been added to the list of members, which now totals 68. Poland withdrew in 1950 and Czechoslovakia was expelled in 1953 because it would not pay its subscription, leaving Yugoslavia as the only Communist member.

Capital and interest rates

The Bank at present has an authorized capital of $21000 million and total subscriptions amount to over $18000 million. The capital subscription of each nation is determined in relation to its economic strength, and only about 10% of it is available to the Bank for lending; the remainder is subject to call only if required to meet the Bank's obligations.

In all, government subscriptions have supplied the Bank with about $1500 million of lending funds in various currencies. In addition the Bank has been able to make large sales of bonds in the capital markets of the world at reasonable interest rates, on the strength of its loan portfolio, its reserves and the guarantees represented by the uncalled portion of its members' capital subscriptions. At the end of October 1959 the Bank had outstanding borrowings equivalent to almost $2000 million. This was the result of many separate operations in investment markets, particularly the United States.

Contrary to the practice of commercial banks, the interest rate charged by the World Bank is not related to the differing risks of projects, but is fixed at the time a loan is signed, having regard to the current bond-market prospects. The rate charged is in fact the rate at which the Bank could raise money at the time a loan is signed, plus a 1% reserve commission and a ¼% administration charge. In 1959 we made three European bond issues at 5% (one in Germany, one in Belgium and one in the United Kingdom) but our major borrowing has been in the United States market. Our present charge to borrowers is 6¼%.

The Bank also sells from its own loan portfolio whenever possible. These sales are usually the earlier maturities, the Bank retaining the latest, and in this way we have been able to increase our resources for further lending by $500 million.

By the 30th September 1959 the Bank had made 241 loans totalling some $4700 million to help finance more than 600 projects in 50 countries or dependencies. The periods of the loans vary with the type of project; for power projects the term is usually 20 years for thermal plant and 25 for hydroelectric plant.

The distribution of the lending has been roughly 30% to Europe, 30% to Asia, 20% to Latin America, 13% to Africa and 7% to Australia. Our largest borrower is India, which alone has received more than $600 million. Australia comes next with $318 million and Brazil and Japan share third place with about $260 million. The Bank's annual rate of lending has grown rapidly in

recent years and is now running at over $700 million per annum.

Lending procedures

With the object of maintaining its credit standing, the Bank has developed lending procedures designed to ensure as far as possible that each of its operations is sound.

Each request to the Bank for a loan has to be sponsored by, and is usually submitted by, the government of the member-country concerned, since the guarantee of the government will be required. The Bank's normal lending takes the form of loans in foreign exchange to finance that part of the cost of a project representing the requirements for imported goods or services. Exceptions are made, however, in the case of countries which are themselves producers of capital equipment, such as Italy and Japan.

The first point on which the Bank wishes to satisfy itself is that the country for which a loan is under consideration will be in a position to service the proposed debt, along with all its other commitments, both existing and prospective. Periodically then the Bank carries out economic surveys in those countries in which loans have been or are expected to be made and sometimes, if unsatisfactory policies are being followed, will make suggestions designed to improve the economic stability and development of the country concerned.

Importance of credit-worthiness

This appraisal of credit-worthiness of member-countries is one of the most important of the Bank's activities because clearly a member's guarantee for one of our loans would have little value if there were likelihood of the member failing to meet its foreign obligations.

Many of the less-developed countries encounter serious economic difficulties from time to time. A number of countries are at present suffering owing to the fall in coffee and cotton prices in the last year or two, so that their foreign-exchange earnings are no longer sufficient to maintain the rate of economic growth which they desire. Lack of proper fiscal control has in many cases saddled the country with excessive short-term external debts, usually in the form of suppliers' credits, and the consequent liability for large annual repayments.

Other countries try to do too much in the public sector, embarking on numerous and costly projects which can only be financed at the expense of the national reserves or by deficit financing with consequent rapid internal inflation, which would lead to balance-of-payments problems.

Power projects represent the largest item in our loan portfolio. About a third of the Bank's development lending has been in this category and has helped to finance the addition of more than 9000 MW to the world's generating capacity—more than the total generating capacity existing in the whole of Latin America at the end of World War II. Another third of our lending has been for transport—railways, highways and ports. The remaining third of the Bank's loans has been for agriculture, for industry and for general development purposes.

National priority of project

In appraising a project for which a loan has been requested, the Bank wishes to satisfy itself first that the project is one which rightly has a high priority in the economic development of the country concerned. This is not always an easy matter to determine, mainly because the relative profitability of different projects is frequently not a sufficient test of their respective contributions to a country's over-all development. For example, a highway system, unless it involves toll roads, yields no direct revenue, but it may foster all kinds of industrial and agricultural activity.

Secondly, the Bank wishes to assure itself that the technical, financial and administrative plans for the project are satisfactory. We have to be satisfied that the engineering plans have been competently drawn, that the project is suitably designed, and that construction will be entrusted to competent hands and will be properly supervised. In making the necessary preparations for a successful project, we believe that considerable advantages can often be obtained if the borrower calls in consultants for the planning, design and supervision of the construction.

In connection with the employment of consulting engineers for the projects which the Bank is helping to finance, it is our policy to leave their selection to the borrower. The Bank must, of course, be satisfied that the firms appointed have had satisfactory experience on comparable projects, that the staff to be assigned to the particular work are qualified, and that the terms of reference on which they are employed are such as to assure satisfactory execution of the project.

In appraising the technical aspects of a project, the Bank limits itself to analysing the studies made by its borrowers and by the borrowers' consultants. The Bank may itself hire consultants for a temporary expansion of its staff or to obtain specific advice on a specialized matter.

International competition for contracts invited

The contractors are also selected by the borrowers, but for the major items the Bank reviews their analysis of tenders and the terms of the final contracts. In giving its approval for the placing of a contract, the Bank has regard to the reputation and experience of the bidder and the forces it can allocate to the job in hand. In accordance with the Bank's charter we are concerned that the borrower should buy as well and as cheaply as he can, and to this end we usually require that wide international competition be invited.

On the financial side we wish to know that the cost

estimates are realistic and that funds for the local-currency expenditures will be available on a sound basis. In the case of revenue-earning projects, such as power projects, we believe that part of the cost should be financed out of retained earnings—in other words, that sound rate policies should be followed. This is particularly important in those countries where no capital market or only a limited one is available, since it ensures that only the minimum amount will have to be assigned to the financing of the project from general taxation, thus making more money available for projects such as roads, schools and hospitals, to which government revenues should more properly be devoted and for which alternative sources of finance are unobtainable.

Unfortunately, the rates charged for public-utility services are all too often influenced by political considerations. In the case of power supplies, the difference between rates which will barely cover costs, and rates which will contribute adequately towards future expansion is rarely an undue additional burden on the consumer and may well represent the difference between an adequate supply and a chronic power shortage. In most cases where the Bank has imposed rate covenants, the rate of load growth has at least equalled our estimates.

If the prospective borrower is an enterprise which, by its nature, has to expand its facilities and consequently will continually require fresh capital, the Bank is interested in ensuring that it will maintain a proper balance between debt and equity capital, that its earnings are likely to be sufficient to yield a reasonable return on its investment, and that its solvency is not endangered by excessive commitments to repay debts on short-term bases. In such cases the Bank may impose an upper limit on the ratio of debt to equity or require that an earnings test be satisfied before further debt can be incurred.

The Ybbs–Persenbeug run-of-the-river hydroelectric project across the Danube in Austria

Establishment of an organizing agency

Perhaps the most important aspect of any project is the management and organization of the agency which will build and operate it. It is difficult to generalize on this since the problems which arise are so varied. One requirement clearly is that there should *be* such an agency, which should have the power to make its own decisions, to create its policies and manage its affairs (particularly its financial affairs) without outside interference. That may seem very obvious, but on occasion the Bank has had to insist on the establishment of such an agency.

Apart from the need for able men at the top of the organization, continuity of management is another necessity which is frequently not provided for, and on which the Bank has to insist.

Although the Bank's conditions are often unpopular at the time the loan is being negotiated, they are in many cases as useful as the loans themselves in the long run. Our interest in the projects we help to finance does not cease with the making of the loans. We follow very closely the construction of each project, the expenditures on it and, after its completion, its operation. We also watch closely the financial situation of the borrower and the development of his business.

Summary

The World Bank has shown a consistent record of effective lending for economic development although its operations are concerned almost entirely with the less-developed countries. The article shows how the Bank applies highly developed lending procedures so as to ensure that lack of technical expertise and financial experience does not impede the successful execution of development projects.

Institution Council Meeting on the 3rd March 1960

THE following summary of reports received and decisions reached by the Council of The Institution at their meeting on the 3rd March 1960 is issued on the authority of the President in a form approved by the Council. It will be understood that this report does not purport to be a complete account of the matters discussed at the meeting, as some items must necessarily be regarded as *sub judice*.

Membership

Taking into account elections up to the 1st March 1960, it was recorded that the total membership of The Institution at that date was 45905.

Regional Advisory Council for Technological Education (London and Home Counties)—Annual Conference

Mr. G. S. C. Lucas, Chairman of the Education and Training Committee, reported that this Annual Conference, to be held in Switzerland this year, would include visits to the Federal Technological University of Zurich, hydroelectric power and civil-engineering schemes in central Switzerland, and the training and educational schemes operated by the firm of Brown-Boveri. It was agreed that Prof. M. W. Humphrey Davies and Mr. N. C. Stamford should attend the conference as the two representatives of the Council on the Electrical Engineering Committee of the Regional Advisory Council.

Institution Prizes

The Examinations Committee had reconsidered the retention of the age limit of 26, above which candidates were at present debarred from receiving Institution Prizes. On the recommendation of the Committee, the Council agreed that this age limit be now abolished, the Finance Committee having confirmed that they would be prepared to meet the small additional expenditure likely to be involved.

Page Prize and Henry Nimmo Prize

The Council approved recommendations from the Examinations Committee that the Page Prize for 1959 should be awarded to Mr. C. T. Gillies and the Henry Nimmo Prize for 1959 to Mr. B. W. Friend.

Mr. Gillies, a student of the Constantine Technical College, Middlesborough, has been selected as an engineering trainee after completing a five-year apprenticeship as an electrical fitter with the North Eastern Electricity Board. Mr. Friend, who, like Mr. Gillies, is 21 years old, is employed on work connected with electronics for thermonuclear projects with the United Kingdom Atomic Energy Authority.

It was noted with interest that the Henry Nimmo Prize was now being awarded for the first time, its value being £15.

Proposed Joint British Committee for Stress Analysis

On the recommendation of the General Purposes Committee, the Council agreed to support proposals formulated at an exploratory meeting, held to discuss the formation of a Joint British Committee for Stress Analysis, which was attended on behalf of The Institution by Prof. A. Tustin and Dr. W. J. Gibbs.

The proposals are:

(i) that a Joint British Committee for Stress Analysis be formed consisting of a representative (and a deputy) from each of several bodies of the learned-society type having an interest in the subject, together with such other bodies as might subsequently be accepted by the Joint Committee

(ii) that its objects should be to act:

> (a) in the collective interest of the constituent bodies by maintaining liaison with the Standing Committee for European or International Conferences on Stress Analysis, including the sending of not more than two delegates to its meetings in Europe
>
> (b) by maintaining liaison with oversea societies and institutes concerned with stress analysis

(iii) that The Institution of Mechanical Engineers be invited to provide the secretariat for the Joint Committee and that a charge not exceeding £30 per annum be paid by each of the constituent bodies to cover costs

(iv) that initially the Joint Committee should operate without a formal constitution

(v) that, if the majority of the bodies represented at the exploratory meeting accepted the proposals, the Joint Committee should hold its first meeting before the 1st May 1960.

In approving these proposals the Council asked the Finance Committee to confirm that they would be in a position to vote the funds necessary to cover the cost of supporting the proposed Joint Committee.

Fuel Efficiency and Power for Industry Exhibition—Institute of Fuel Organizing Committee

The Council supported a suggestion that the above Committee, on which they are represented by Mr. H. V. Pugh, should become a permanent Advisory Committee to handle the technical meetings run in conjunction with the Exhibition, as this seemed likely to become a biennial event.

Council nominations

Following their long-established procedure, the Council then selected, from names put forward by members of Council, the nominations to be made in accordance with Bye-law 49 to fill the vacancies which will arise on the 1st October 1960. The names of those whom the Council

decided to invite to accept nomination are given in the notice which is being circulated with this issue of the *Journal*, and biographical details of the nominees appear on p. 252.

Visit to Poland

The President and the Secretary of The Institution had been invited by His Excellency Henryk Golanski, Minister of Higher Education, and Prof. J. Tymowski, Principal of the Warsaw Technical University, to visit Poland from the 2nd to 10th April 1960, to follow up discussions held in this country at the end of 1959 with Mr. Golanski on the technological education of electrical engineers. The opportunity would be taken of inspecting the educational facilities available to engineers in Poland, and the visitors would be the guests of the Polish Government while in that country, transport being provided by the British Council.

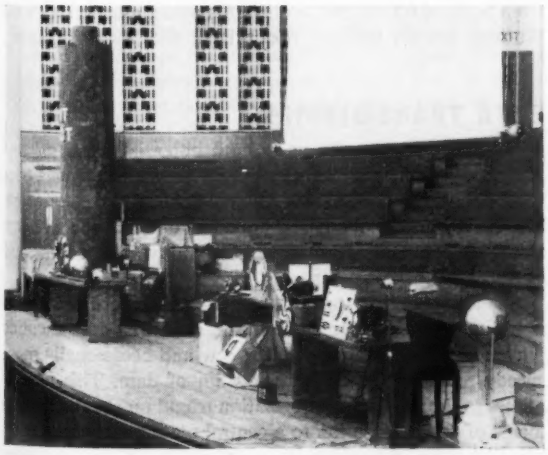
The Council welcomed these invitations and agreed that they should be accepted.

Professor Say's Faraday Lecture

WITHOUT doubt, the best-attended meetings organized by The Institution are the annual Faraday Lectures. In London, as elsewhere, the 'House Full' notices go up some days in advance of the Lecture, and members and others who have left their applications for tickets a little on the late side are disappointed. ('But you *must* let me have a ticket—I'm a member'; 'Sorry, sir, so are 45000 others'.)

So it was for Prof. M. G. Say's Lecture on 'Electrical machines' at the Central Hall, Westminster, on the 17th February 1960. Over 2400 tickets were issued—well in excess of the available seating, to allow for 'wastage'—and still literally dozens of applications had to be refused. Prof. Say's experience with this Lecture has been similar to that of his predecessors—crowded halls, requests for additional Lectures, everywhere tremendous enthusiasm.

Apart from the London meeting, Prof. Say is giving the Lecture in Glasgow, Edinburgh, Sheffield, Nottingham, Birmingham, Cardiff, Southampton, Rugby, Hanley, Liverpool, Belfast and Dublin; and at several of these places additional Lectures are being given to audiences of senior school-children, so that by the time he has finished his tour he will have 'played' to audiences totalling some 25–30000.



The demonstration equipments await the Lecturer at Liverpool

At the Central Hall

The audience at the Central Hall in the City of Westminster on Wednesday, the 17th February, may be taken as fairly typical of the audiences Prof. Say is meeting at his other Lectures: a mixture of members, their wives and friends, 'the general public'—school-teachers, senior school-children and so on—and, for London only, the President of The Institution and Lady Jackson and past and present members of Council and their ladies.

The doors opened at 5.30 p.m., but long before that the queues were forming—the old hands know where the best seats are and arrive early to make sure of getting them. During the next 30 minutes some 2000 people arrived and were shown to their seats by stewards provided from the Institution staff. At 6 p.m. the President led the Lecturer onto the stage and introduced him to the audience.

Prof. Say, who for 27 years has held the Chair of Electrical Engineering at Heriot-Watt College, Edinburgh, is well known to many members of The Institution through the appointment he holds, the books he has written, his service on the Supply Section Committee of which he was elected Chairman in 1957, and his many other activities. He has gained a well deserved reputation as a lecturer who manages to bring more than the usual degree of life to his subject.

Electrical machines are Prof. Say's speciality and it was not unnatural that the Council should turn to him when they were contemplating a Faraday Lecture on that subject. Obviously Prof. Say has not the resources of a large organization such as many Lecturers have had in recent years, and to that extent his difficulties were increased. However, he has many friends in the industry and, as members who have seen the Lecture will agree, he was able to assemble a most attractive series of demonstrations which, supported by film and slides and by his own natural deftness as a lecturer, combined to make a Lecture with extraordinary directness of appeal.

Faraday to Zeta

One is tempted to remark that Prof. Say dealt with electrical machines from F to Z—Faraday to Zeta. His Lecture rested more directly on the pioneering experiments of Faraday than

any other Faraday Lecture of recent years, and he took full advantage of this to develop his theme and to fulfil one of the main objects of these Lectures, the commemoration of Faraday himself.

Prof. Say first introduced us to electrostatic machines and to magnetic machines of various kinds. These Lectures are intended for the layman, and it was evident from the way in which he took his audience from one simple lesson with its accompanying demonstration or slide to the next that Prof. Say had taken this to heart. Having described the Van de Graaff machine—and given a 'wig-raising' demonstration of electrostatic power—he passed to a simple exposition of rotating electromagnetic machines and the everyday uses to which they are put—food mixers, dry shavers, 'do it yourself' gadgets, toys, trains, coal cutters, etc.

After giving his audience a nodding acquaintance with his subject, he turned the pages back to the very start of the story—to Faraday, his discovery of the principle of electromagnetic induction and the first-ever electric motor, the Faraday disc. He remarked that no one had since been able to add anything to the fundamentals of Faraday's discoveries.

Leading by easy stages through the commercial applications of the principle in the second half of the 19th century to the complications of modern electromagnetic motors—d.c. induction and synchronous—he explained with film and demonstrations the arrangements necessary to maintain cross-magnetization and speed control. Motors of all shapes and sizes—midget, flat, tubular and spherical—were introduced to the audience, who showed by their applause how much they appreciated the trouble Prof. Say had taken in choosing films and demonstrations to illustrate his Lecture.

Looking to the future he mentioned the possibility of 'Douglas Baders' having powered artificial limbs actuated from the brain of the wearer by nerve impulses. One of the models used to demonstrate the possibility of the rotor travelling along the stator, moved across the stage propelled by motors which resembled a caterpillar track. His final demonstration was of a tubular stator. A dartboard was placed at right-angles to this at a distance of a few yards, and at the touch of a switch the stator 'fired' a rod-dart which on the third attempt scored a 'bull', much to the satisfaction of the audience.

Prof. Say delivering the Lecture at the Philharmonic Hall, Liverpool, on the 10th March 1960

For 90 minutes Prof. Say spoke and with apparently casually injected and obviously appreciated humour held the interest of his hearers—even when the impossible happened and the operator managed to put a film in the wrong way round.

Sir Willis Jackson's expression of thanks to Prof. Say and his assistant, Mr. G. Boal, at the conclusion of the Lecture was carried with what is usually described as 'thunderous' applause. Perhaps among the 'credits' room should also have been found for Mrs. Say, who for the duration of the Lecture tour has to be resigned to losing her husband for a week at a time while he is over the Border 'on tour for The Institution'.

NEW SIGNAL-BOXES

Work has begun on a new power-operated signal-box at Liverpool, Edge Hill and is expected to be completed by July 1961. A new miniature control panel, the first of its kind in the London Midland Region of British Railways, will be employed in the box, which will supersede four existing mechanical boxes. Pushbuttons will be positioned on a track diagram in correct geographical relationship, and each signalled movement will be initiated by the operation of two pushbuttons which will control the entrance to and exit from the section concerned. This system, with modern colour-light signals, continuous track circuiting and electro-pneumatically operated points, will completely replace the existing mechanical signalling in the area.

London Transport have opened a new signal-box at Amersham, the future terminus of the Metropolitan Line. The box controls colour-light signals and power-operated points from a pushbutton console. The work is part of a £9 million scheme (including the provision of new rolling-stock) for the electrification of the Metropolitan Line from Rickmansworth to Amersham and Chesham, and the four-tracking of the line from Harrow on the Hill northwards to the junction with the Watford branch between Moor Park and Rickmansworth.

DATA TRANSMISSION

Electronic-computer users, and potential users of data transmission, are being asked by the British Post Office what data-transmission facilities may be needed in the future. The survey covers about 350 organizations, including banks, insurance companies, finance houses, industrial concerns and Government departments.

As more and more computer and punched-card equipment is brought into use for commercial, industrial and scientific purposes, the necessity arises for new and occasionally more speedy methods for the transmission of data. This usually relates to the sending of information from branches or departments of an organization to a central place for processing by computer or puched-card apparatus and sometimes the return of information to the originating point after processing.

Lightning protection of overhead lines

A short article based on a Supply Section paper (3172) entitled 'The shielding of overhead lines against lightning' by J. H. Gridley, Ph.D., B.Sc.(Eng.), Associate Member. The paper was published individually in January 1960 and will be republished in Part A of the Proceedings. It was read at an Ordinary Meeting at Savoy Place on the 4th February 1960 (see p. 261).*
The author is Head of the Electrical Engineering Department, Regent Street Polytechnic, London.

MANY overhead electricity supply systems suffer more faults from lightning than from any other cause. Distribution systems in the 6·6–33 kV range may be affected either by induction from a nearby lightning stroke to earth or by a direct stroke to the conductors or supports. At the higher voltages of bulk transmission, flashover due to nearby strokes is unlikely and most lightning flashovers are due to overvoltage caused by the discharge of lightning current into the system. If an overhead system could be as completely shielded from lightning as a buried cable system, lightning flashover would be rare indeed.

Although such complete shielding is uneconomic the phase conductors can be protected to some degree by the installation of an overrunning wire connected to earth at each tower or support. It is probable that an earth wire installed vertically above a conductor would provide nearly perfect shielding. Conversely, few transmission engineers would claim that an earth wire in the same horizontal plane as a phase conductor would be at all adequate. Otherwise, there is no general measure of agreement on the optimum disposition of an earth wire required to shield a group of conductors.

Theory of the shielding effect

It is well known that long laboratory sparks often involve two streamers, one developing from each electrode; a complete conducting path is formed when the streamers join. It is equally well known that a normal lightning flash to earth is preceded by a streamer developing from a charged cloud (the leader stroke), and there is evidence that a path to earth is completed by an upward streamer from earth. The fraction of the cloud-to-earth path covered by the upward streamer is probably quite small, for the leader must descend to quite low levels before it causes an electric field intense enough to produce a streamer from earth.

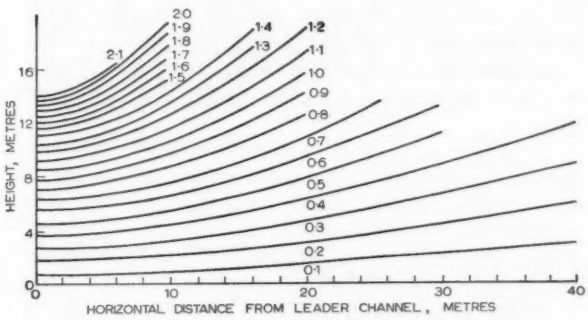
When a transmission line is struck an upward streamer must arise from the supports or conductors. It follows that an earth wire is effectively installed if an upward streamer will always occur from it before one can occur from a phase conductor. Now the electric force at the surface of an earth wire or phase conductor is primarily determined by the bound charge induced on it by the descending leader stroke. If an earth wire and phase conductor carry equal bound charges they are to a first approximation equally likely to initiate upward streamers and therefore equally likely to be struck. Two elementary equations give approximate values for the charges induced per unit length of the earth wire and phase conductor:

$$q_e + C_e V_e = 0 \quad \text{and} \quad q_c + C_c V_c = 0$$

The implicit assumption is that both wires remain near earth potential by virtue of the induced charges which they acquire; thus q_e is the charge per unit length acquired by the earth wire, C_e its capacitance per unit length and V_e the prospective potential at the point in space where it is installed, i.e. the potential which would be impressed at that point by the leader charge in the absence of the earth wire.

Equipotential curves

Since the earth capacitances of the wires will not be materially different, it follows that equal bound charges imply equal prospective potentials. If equipotential curves are drawn for a descending leader stroke (Fig. 1) and a conductor is imagined to lie on one of these curves with its axis perpendicular to the plane of the paper, the limiting effective position for an overrunning earth wire can be deduced from the requirement that it must lie on the same curve.



1 *Equipotentials of electric field of leader channel*

Potentials shown are multiples of $q_0/4\pi\epsilon_0$ and can be converted to megavolts for $q_0 = 10^{-3}$C/m by multiplication by 8·98

When many field plots are made for different leader-tip heights and distances from the transmission line, a corresponding range of limiting positions for the earth wire can be found. On the principle that only intense strokes will affect the line from the greater distances and that feeble strokes which would not endanger the line insulation are of no consequence, the

*This article and those following are based on, and written by the authors of, current Institution papers. The authors have been asked to make these articles so far as possible interesting and of appeal to electrical engineers who have no specialized knowledge of the topics, and the content of the articles is not necessarily confined to the subject-matter of the original papers

limiting position can be made a function of stroke intensity (as measured by peak current).

It is then found that if an earth-wire position is adequate to protect against strokes of low peak current it is also adequate for strokes of higher peak current. If a line joining earth wire and phase conductor makes an angle of about 45° to the vertical, shielding is adequate for strokes of peak current which would just cause flashover on 132kV lines, and by the above theory this angle is adequate for lines of 132kV and over.

Published power-system statistics lend some support to the foregoing but cannot be said to present a consistent enough picture to enable firm conclusions to be reached. There is clearly much useful work to be done in the compilation and publication of lightning-fault statistics. 621.316.98

Commutation and the oscillograph

A brief account of a Measurement and Control Section paper (2955) entitled 'A new method for observing the phenomena of commutation' by H. J. H. Sketch, B.Sc.(Eng.), Associate Member, P. A. Shaw, B.Sc.(Eng.), and R. J. K. Splatt. The paper was published individually in June 1959 and will be republished in Part A of the Proceedings. It was read before a joint meeting of the Measurement and Control, Supply, and Utilization Sections on the 5th January 1960 at Savoy Place (see p. 258). The authors are at the Royal Aircraft Establishment.

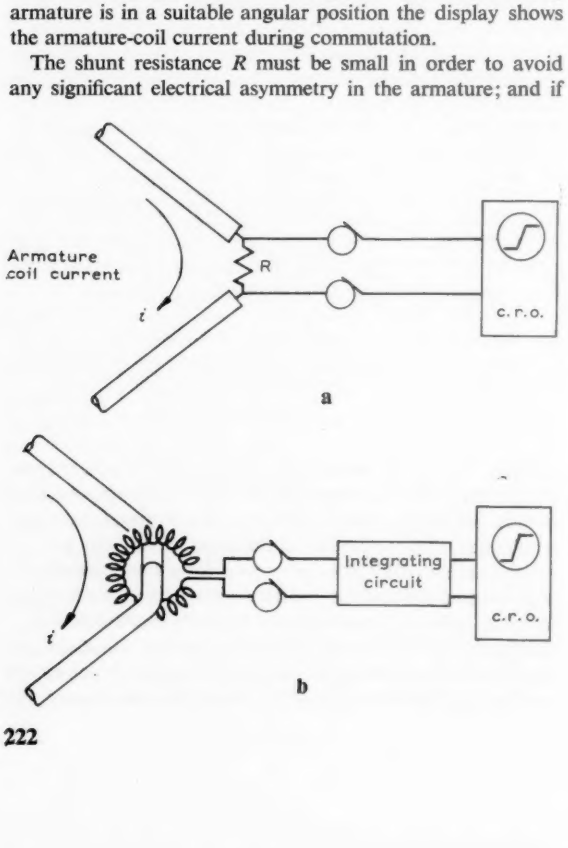
In some cases the cause of poor commutation in a d.c. machine can be determined by measuring the armature-coil current during the commutation interval. One method of measurement uses a shunt in series with an armature coil as shown in Fig. 1a. The potential leads are taken to slip-rings temporarily secured to the armature shaft, and the amplified signal is applied to the Y-plates of a cathode-ray tube (c.r.o.). If the oscillograph time-base is triggered when the rotating armature is in a suitable angular position the display shows the armature-coil current during commutation.

The shunt resistance R must be small in order to avoid any significant electrical asymmetry in the armature; and if the measurement of current is to be reasonably accurate the drop in potential across the shunt must be large compared with any e.m.f. induced in the circuit formed by the shunt and potential leads. With some machines and in particular with those having a very high rate of change of armature-coil current during commutation, it is impossible in practice to find a satisfactory compromise between these conflicting requirements.

The new method

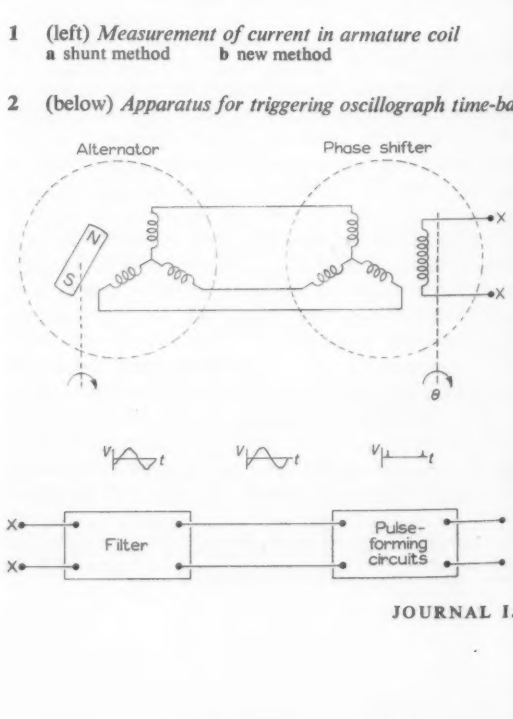
A new method of measurement is outlined in Fig. 1b. One armature coil is broken and then remade so that it links a small toroidal search coil. The e.m.f. induced in the search coil, which is proportional to the rate of change of armature-coil current, is integrated by a simple CR network to give a signal proportional to the armature-coil current itself.

This method has been found satisfactory where a high rate of change of armature-coil current during commutation has precluded the use of a shunt. A search coil of toroidal form helps to ensure that the e.m.f. induced is predominantly due to the magnetic field associated with the selected armature coil. Any remaining stray induced e.m.f.'s may be measured



1 (left) *Measurement of current in armature coil*
a shunt method **b** new method

2 (below) *Apparatus for triggering oscillograph time-base*



by running the machine with the toroid in position but before the armature coil is linked with it.

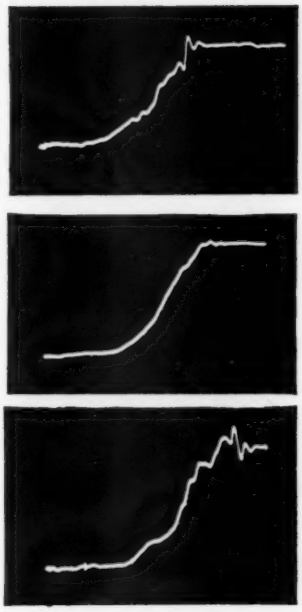
Triggering the time-base

Fig. 2 shows the apparatus used to trigger the oscillograph time-base. A small permanent magnet fitted to the armature shaft runs in a stator carrying a 3-phase winding, and together they form a small alternator which supplies a synchro used as a phase shifter. The frequency of the signal available at XX is such that one complete cycle occurs per revolution of the d.c. machine; and the phase, relative to the rotation of the armature, depends on the rotor angle θ which is set manually. The signal is filtered, squared and differentiated, and the resulting pulses are used to trigger the oscillograph time-base.

With this arrangement any commutation position may be selected for examination by moving the rotor to the appropriate angle, and a suitable sweep time can be chosen with the normal oscillograph control. The apparatus may be adapted to obtain a record, on one frame of photographic film, of current reversals as they occur in a number of consecutive machine revolutions.

Fig. 3 shows oscillograms of armature-coil current with the interpole excitation adjusted to show under-commutation, normal commutation and over-commutation.

621.313.2.047.2 : 621.317.312



3 *Typical oscillograms*

HOUSING-ESTATE DISTRIBUTION SYSTEMS

A brief account of a Supply Section paper (3131) entitled 'The design of housing-estate distribution systems using a digital computer' by R. L. Grimsdale, M.Sc., Ph.D., Graduate, and P. H. Sinclare, M.Sc., Associate Member. The paper was published individually in December 1959 and was read before the Supply Section on the 10th February 1960 at Savoy Place (see p. 259). It will be republished in Part A of the Proceedings. Dr. Grimsdale is, and Mr. Sinclare was formerly, at the University of Manchester. Mr. Sinclare is now with the Yorkshire Electricity Board.

THE selection of substation sites and feeding routes for housing-estate networks demands considerable experience and skill of the planning engineer. All alternatives should be investigated so that the final design is the cheapest possible lay-out which satisfies the given engineering criteria of ultimate electrical load and voltage drop, cable loadings and interconnection facilities.

Although the number of substation sites is limited in practice by amenity considerations, it would be quite impracticable to repeat for every possible alternative the tedious calculations which are necessary to ensure compliance with the engineering requirements. The planning engineer therefore relies largely on an intuitive approach for site and cable-route selection and then proceeds with the detailed calculations.

The automatic method replaces the engineer's intuition by repeated computations which approach the optimum design more closely step by step. The calculations which are normally performed by slide-rule are of course also mechanized. A large general-purpose digital computer with addition speeds of the order of 0·1 millisec is necessary to make automatic design economically feasible.

Determination of substation positions

The first part of the automatic design programme selects ideal substation positions. The criterion for the selection process demands that every substation should be placed at the centre of gravity of the load which it feeds. The process commences with arbitrary starting substation positions and progressively improves these positions during a number of steps. Each step consists of two basic moves:

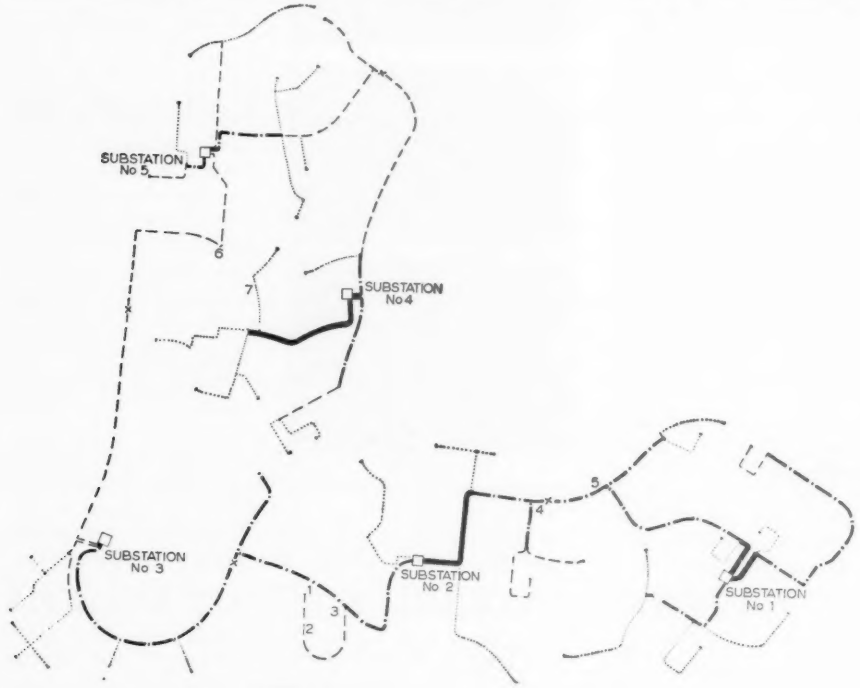
(1) for each unit square (the estate area being divided into unit squares of $\frac{1}{4}$ acre) the machine selects the nearest substation position, thus accumulating a supply area for each substation

(2) the centre of gravity of load is then calculated for each supply area and is taken for the new, improved substation position.

The basic moves are repeated until there are no significant improvements between successive steps. Certain choices of starting position may restrict the free movement of substations during the repetitive process and produce non-optimum solutions. The whole process is therefore repeated four times with different starting-points, and the set of results with the lowest cost is chosen as the ideal set of substation positions.

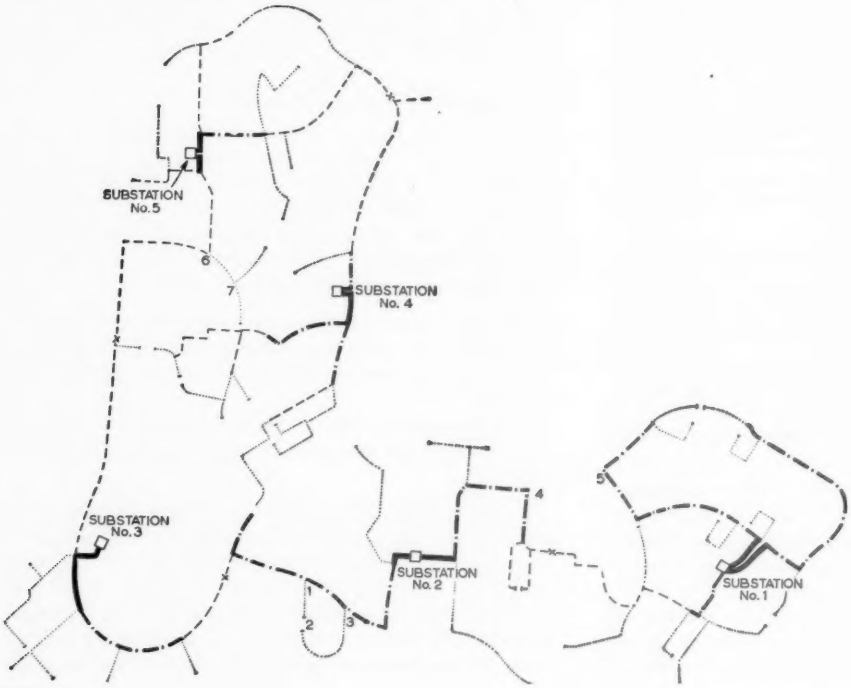
For a five-substation estate this calculation is completed in approximately 2min using the suggested computing speeds.

The ideal substation positions are not practical sites as the road and housing lay-outs are ignored during the selection process. The automatic design is therefore interrupted after the ideal substation positions have been printed out by the computer. The design engineer can now choose several feasible sites in the vicinity of each ideal position and these are used in the automatic network design.



1 *Manual design for estate no. 2*

□ substation × link box
Cross-sectional area of cable:
0·2in.²
0·06in.²
0·1in.²
0·04in.²



2 *Automatic design, using actual substation sites*

□ substation × link box
Cross-sectional area of cable:
0·2in.²
0·06in.²
0·1in.²
0·04in.²

M.V. network design scheme

The first step in the network design is the selection of the shortest feeding route for each section of road on the estate. This presents a maze problem to the machine and all possible routes, including many trivial alternatives, have to be tried. Although the selective capacity of the human eye is superior, the machine is more efficient in this process owing to the speed and accuracy with which the many alternative routes

3 *Automatic input of a road network*

a map of road network
b picture received from scanner, displayed on the computer console
c roads reduced to single-spaced digits (computer console)

are examined. Theoretical cable sizes are calculated to use up the whole of the available voltage drop, and practical sizes based on these are chosen with due regard to interconnection facilities, and the total cost is calculated.

The first design is improved by trying slightly different feeding routes, taking excavation and jointing costs into account. Further tentative designs are prepared using other feasible sites in the vicinity of the ideal substation positions, the final design being considered the optimum distribution system. This is printed out with details of cable sizes, load and voltage drop for each road section.

Comparisons and analyses

Four automatic designs were compared with carefully prepared hand designs and in all cases useful savings were achieved by the computer, after allowing for the higher cost of design preparation.

Accurate comparisons are difficult as planning engineers often provide a greater number of substation outlets and better interconnection facilities than are justified either on economic grounds or on the given engineering criteria. Also it was desirable to analyse separately the effects of the automatic substation-site selection and of the automatic cable-design scheme. Three variants of the automatic design were therefore compared with the manual design:

(1) Using calculated substation positions and providing the minimum facilities, the maximum savings were obtained
(2) Actual sites were used in the automatic design and minimum facilities provided (Figs. 1 and 2). The savings were observed to be smaller in this comparison, thus indicating the superiority of the computed sites
(3) The automatic design using actual substation sites was adjusted to allow for the same excess facilities which the planning engineer provided. Savings, though further reduced, were still achieved in this case. They were mainly due to the trials with alternative feeding routes (e.g. road sections 4–5, 6–7, 1–2–3) which are undertaken by the computer.

In some cases the computed and actual substation sites coincided. It is also possible that in some of the other cases the designer would have preferred sites near the ideal positions but could not obtain them. In this connection a useful feature of the automatic method is the possibility for rapid assessment of the relative values of different sites.

The design programme could easily be extended to include the economic consideration of distribution losses, and the substation-site selection process could be applied to the planning of reinforcement schemes for higher voltage levels. Investigations such as the determination of the optimum number of standard cable sizes or the cost effects of varying basic engineering criteria could readily be carried out.

As well as reducing capital expenditure, the adoption of the automatic method would save skilled manpower, although the present input technique is somewhat tedious and an automatic input system is therefore advocated. Experiments proved that such a system was feasible (Fig. 3).

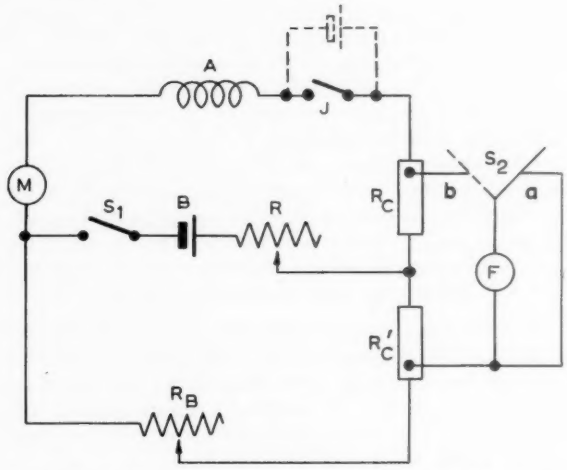
The automatic design method has proved useful in providing standards for assessing manual designs. It has shown that the experienced planning engineer often achieves designs which are similar in many respects to the automatic designs, but detailed comparisons suggest that the computer is superior owing to its inherent greater capacity for detailed calculation and its higher consistency.

621.316.17 : 681.142

Measurement of inductances of electrical machines

A short account based on a Measurement and Control Section paper (2871) entitled 'A method of measuring self-inductances applicable to large electrical machines' by Prof. J. C. Prescott, D.Eng., Member, and A. K. El-Kharashi, B.Sc. The paper was published in the Proceedings, Vol. 106, Part A, p. 169. It was read at Savoy Place on the 5th January 1960 at a joint meeting of the Measurement and Control, Supply and Utilization Sections (see p. 258). *Prof. Prescott is Professor of Electrical Engineering, King's College, University of Durham, and Mr. El-Kharashi is in the Department of Electrical Engineering there, on study leave from Ain-Shams University, Egypt.*

THE Maxwell–Rayleigh bridge used with a ballistic galvanometer is a well known means of measuring self-inductance but difficulties arise when an attempt is made to apply it to the measurement of inductances having large time-constants.*



1 *Bridge circuit for measuring the apparent self-inductance of a coil as a function of time*

Description of the method

These difficulties can be overcome by replacing the ballistic galvanometer by a fluxmeter F (Fig. 1). This can be either short-circuited with switch S_2 on **a**, or connected with S_2 on **b** across the equal low-resistance shunts R_C and R_C'. The self-inductance to be measured is represented by the coil A connected in the upper mesh of the bridge, the resistance of which can be matched by adjusting a non-inductive resistor R_B in the lower mesh. The battery supplies current to A which can be measured by the ammeter M, adjusted by the variable resistor R and interrupted by the switch S_1. The dotted circuit across the switch J, which is normally closed, is used to introduce a known number of volt-seconds into the upper mesh of the balanced bridge for the purpose of calibration.

After calibration J and S_1 are closed and with S_2 on **b** the bridge is again brought into balance, as shown by the fluxmeter pointer coming to rest, by adjustment of R_B.

The current I_0 in A is read on M and S_1 is opened; the bridge is thus put out of balance by the inductive e.m.f. generated in A, and the total change in flux linkage in A is measured by the throw of the fluxmeter. If this change is Φ, then by definition the coefficient of self-inductance L is given by $L = \Phi/I_0$ if I_0 has been allowed to fall to zero.

Practical application

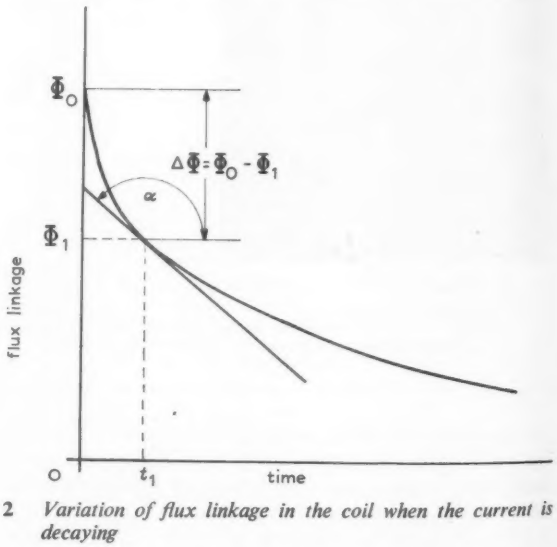
The fluxmeter bridge has been found particularly useful for measuring the subtransient, transient and steady-state inductances of synchronous machines. The throw of the fluxmeter measures the total change in flux linkage occurring while it is connected in the circuit.

By using suitable switching circuits it is possible to arrange that the fluxmeter shall remain short-circuited (S_2 on **a**) until a known time interval has elapsed after the opening of S_1 and shall then be connected across the shunts R_C and R_C' by moving S_2 instantaneously to **b**, where it will remain till the current in the inductance has fallen to zero.

By increasing t in steps from zero, keeping the initial current I_0 in A the same for each reading, the curve of Fig. 2 may be obtained connecting flux linkage and time. The coefficient of self-inductance over the interval $(0 - t_1)$ may be written:

$$L_{t_1} = \frac{\Phi_0 - \Phi_1}{I_0 - I_1}$$

in which I_1, the current in A at time t_1, remains to be defined.



2 *Variation of flux linkage in the coil when the current is decaying*

$$\tan \alpha = (d\Phi/dt)_{t=t_1}$$

* See JONES, C. V.: 'An analysis of commutation for the unified-machine theory', *Proceedings I.E.E.*, Monograph No. 302U, April 1958 (105 C, p. 476)

Remembering that the resistance of the shunts will be negligible as compared with that of the fluxmeter and that the switch S_1 will be open when I_1 flows, we may write:

$$I_1 = \frac{-1}{R_C + R'_C + R_A + R_B} \left(\frac{d\Phi}{dt}\right)_{t=t_1}$$

Since $(d\Phi/dt)_{t=t_1}$ is the slope of the curve at t_1, the value of I_1 and thus of L_{t_1} is defined. Taking progressively increasing values of t it is possible to calculate the self-inductance over various time intervals, e.g. $(t_1 - t_2)$ etc., and so obtain the subtransient, transient, and synchronous values.

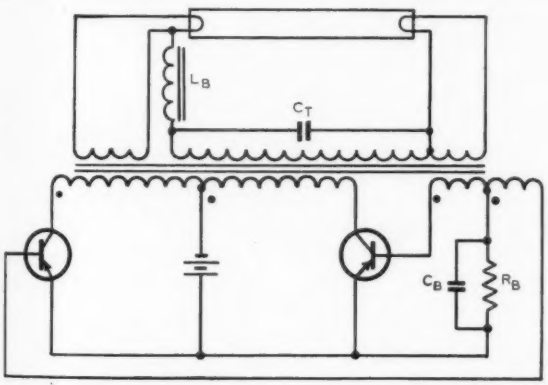
621.313.32 : 621.317.334

Transistor-inverter operation of fluorescent lamps

A short article based on a Utilization Section paper (3192) entitled 'The application of power transistors to the operation of gas-discharge lamps from d.c. supplies' by I. F. Davies, B.Sc., Associate Member, and D. Dunthorne, B.Sc.(Eng.), Graduate. The paper was published individually in January 1960 and will be republished in Part A of the Proceedings. It was read before the Utilization Section on the 14th January 1960 at Savoy Place (see p. 256). Mr. Dunthorne is, and Mr. Davies was formerly, with the General Electric Co. Ltd. Mr. Davies is now with Philips Electrical Ltd.

SINCE the introduction of tubular fluorescent lamps there has been a small but continuous demand for their operation from direct-current supplies.

In general it has been possible to operate fluorescent lamps of various sizes from nominal d.c. supplies as low as 72 volts, but this has always been accompanied by two undesirable features. These are the high electrical losses in the resistor required to ballast the lamp and the phenomenon of cataphoresis, whereby the positively charged mercury ions in the lamp travel towards the lamp cathode, resulting in a low light output at the anode end of the lamp.

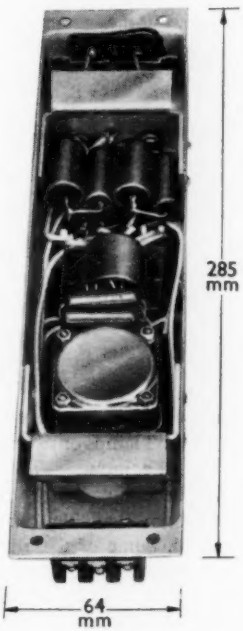


1 *Push-pull sine-wave inverter*

Vibrator and rotary inverters

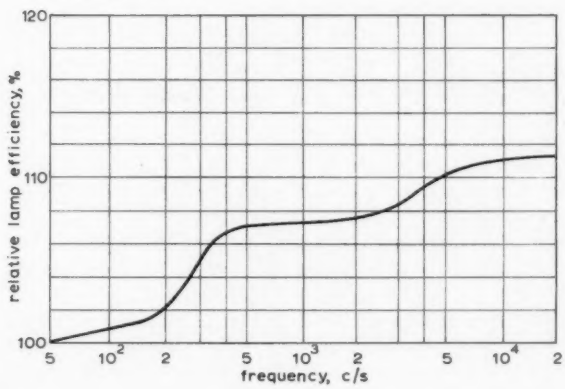
The use of fluorescent lamps on d.c. supplies of less than 72 volts, such as are found in trains, aircraft, etc., has been possible only via vibrators or rotary inverters of various types, and these all suffer from the usual maintenance problems associated with equipment having moving components. The employment of vibrators and rotary inverters, however, has made it possible for the lamps to be operated from the alternating supply derived therefrom, and thus to eliminate the disadvantages of d.c. operation mentioned earlier.

From this it is a logical development to design a static



2 (right) *40 watt 28 volt d.c. inverter*

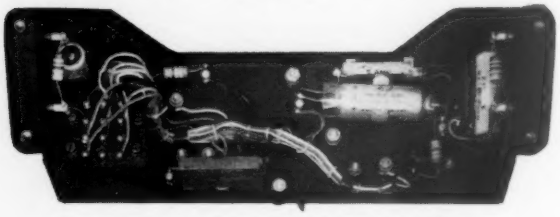
3 (below) *Relative lamp efficiency as a function of frequency for 40 watt fluorescent lamp operating at 40 watts*



inverter, but until recently this was not possible where low-voltage supplies were concerned.

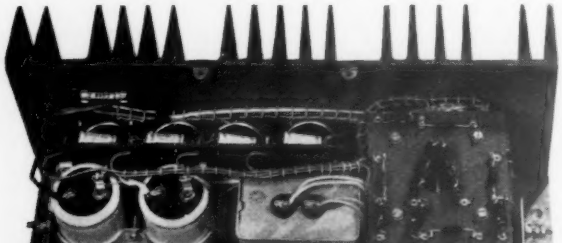
Transistor inverters

During the last few years the introduction of power transistors has made possible the design of small, and highly efficient, static inverters capable of operating one or more fluorescent lamps on an alternating supply derived from a low-voltage d.c. input.



4 *16 watt 28 volt d.c. inverter for Vanguard airliner*

5 *110 volt d.c. power-pack inverter for British Railways*



In the comparatively short time that transistor inverters have been available, many circuit arrangements have been evolved. Some of these have a square output-voltage waveform and others a sine waveform. For several reasons the sine-wave inverter is to be preferred in this instance.

The sine-wave transistor inverter for lamp operation is basically a self-driven tuned-collector oscillator of conventional design.* The complete circuit diagram of a push-pull inverter is shown in Fig. 1. The lamp is inductively ballasted and operated from a secondary winding on the oscillator transformer; the lamp cathodes are continuously preheated via further transformer windings. The capacitor C_T acts partly as power-factor correction for the lamp circuit and partly as tuning for the oscillator. The resistor R_B controls the drive to the transistors, and capacitor C_B controls the class C conditions of the inverter.

An inverter of this type can operate a 40 watt fluorescent lamp from a 28 volt d.c. supply and have an over-all efficiency of 75%. Such an inverter is depicted in Fig. 2.

Factors in inverter design

The operating frequency of lamp inverters is determined by several factors. Fig. 3 illustrates the manner in which the light output of a 40 watt fluorescent lamp increases with frequency, showing that an operating frequency of about 20 kc/s is desirable. A frequency in this region, i.e. above the audio range, also enables the designer to dispense with any heavy clamping arrangements that may be necessary to ensure quiet operation of wound components at frequencies in the audio range. One disadvantage of using a high frequency is that while the wound components are smaller and lighter, in some cases they may be more expensive than lower-frequency types.

In practice the cut-off frequency of power transistors puts the upper frequency at about 10 kc/s.

Other factors in the design of transistor inverters for lighting purposes involve adequate cooling of the transistors, design of capacitors for h.f. use, and suitable circuit design to ensure safe operation of the inverter when it is subjected to the high-energy surges found frequently on transport d.c. supplies.

Installations

Lighting inverters have been installed during the last two years in railway coaches (British Railways and London Transport Executive), buses and aircraft. A 16 watt inverter for the Vanguard airliner is illustrated in Fig. 4; and Fig. 5 shows a 110 volt d.c. inverter, designed to operate four 40 watt fluorescent lamps, for railway use.

621.327.534.15 : 621.311.6 : 621.382.3

* CRIPPS, L. G.: 'Low-frequency transistor oscillators', *Mullard Technical Communications*, 1957, 3, p. 44

Logical design of electrical networks

A résumé of a Supply Section paper (3138) entitled 'The logical design of electrical networks using linear-programming methods' by U. G. W. Knight, B.Sc.(Eng.), Associate Member. The paper was published individually in November 1959 and will be reprinted in Part A of the Proceedings (see p. 259). The author is with the Central Electricity Generating Board.

In common with many other engineering-design problems, the planning of an electricity-supply network is usually done by analysing and costing a number of trial designs and selecting from these the design or combination of designs which is the best compromise of technical merit and cost. The objection to this procedure is that the trial designs are obtained intuitively rather than logically and hence there is no certainty that all the near-optimum designs have been considered. The technique of linear programming allied with the use of digital computers has enabled the network-design problem to be approached in a logical rather than intuitive manner.

As is well known, a set of simultaneous linear equations

cannot be solved to obtain a unique solution for the variables when the number of variables exceeds the number of equations. Linear programming (l.p.) however enables that particular solution for the variables to be obtained which will minimize or maximize, as one wishes, a given linear function of the variables. The arithmetic operations required are very simple but their number is such that in most practical applications of l.p. it is necessary to use a digital computer to obtain the required solution.

Outline of the method

It is assumed in the method developed that the basic information available for designing the network is the geographical position of the substations which it is required to interconnect, the net load or generation at these substations, the rated capacity of the cables or overhead lines it is proposed to use on the network, and the routes or paths between substations along which circuits can be provided.

Denoting a path between substations S_i and S_j as p_{ij} the aim of the analysis is to assign a value 0, 1 or 2, etc. to each p_{ij}, denoting that 0, 1 or 2, etc. circuits will be required along this path. This is done by minimizing the sum $\sum_{ij} c_{ij}p_{ij}$ (where c_{ij} is the estimated cost of one circuit along path p_{ij}) subject to a set of equations or constraints in p_{ij} defining mainly the required security of supply in the proposed network.

At this stage of the problem one has no knowledge of what interconnection will be required in the network and it is necessary therefore to specify the minimum number of circuits required into every substation, every possible group of two substations, every possible group of three substations, and so on. The network-design problem is then reduced to the solution of a linear programme of the form:

minimize $\sum_{ij} c_{ij}p_{ij}$

subject to $\sum_i p_{ij} \geqslant A_j$ (for substation S_j, one of n equations where $n =$ number of substations at which security has to be defined)

$\sum_i p_{ij} + \sum_i p_{ik} \geqslant A_{jk}$ (for substations S_j and S_k, one of ${}^nC_2 = \frac{1}{2}n(n-1)$ equations)

and so on for all groups of 3, 4 . . . n substations

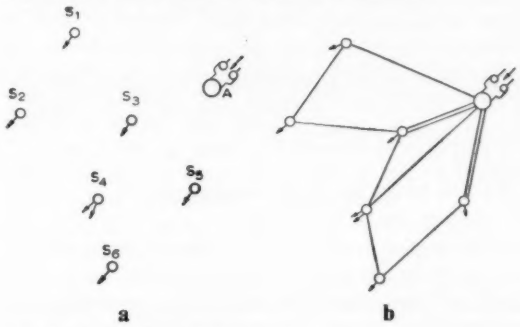
and $p_{ij} = 0$ or 1 or 2, etc.

In these equations A_j, A_{jk}, etc. are whole numbers obtained by dividing the net power demand or surplus of the substation group by the rated circuit capacity, raising the quotient to the next higher integer and adding a small integer. The addition of the small integer is necessary to ensure there is no loss of supply in circuit-outage conditions, its value depending on the degree of security required in the proposed network.

Where necessary, additional constraints can be added to limit the number of circuits along any one route or into a substation. Constraints of the latter type can be used as a means of limiting network fault levels.

If there are m substations at which it is not necessary to specify security, e.g. firm supply points to the proposed network from a higher-voltage network, and n at which security has to be specified, there will be ${}^{(m+n)}C_2$ possible paths along which circuits could be built and $2^n - 1$ constraints to specify network security.

Hence the network design requires the solution of a linear programme of ${}^{(m+n)}C_2$ variables in $2^n - 1$ constraints. The storage of the computer used to solve a linear programme must at least exceed the product of these two figures, and this restriction places a rather low limit at present on the number of substations for which a design can be obtained.



1 *A 7-substation design*

Supply substation Load substation

a Geographical disposition of substations and estimated cost of one circuit per path

path	cost per circuit £ × 10³	path	cost per circuit £ × 10³
p_{A1}	312	p_{23}	238
p_{A2}	352	p_{24}	251
p_{A3}	193	p_{25}	365
p_{A4}	299	p_{26}	343
p_{A5}	315	p_{34}	224
p_{A6}	391	p_{35}	230
p_{12}	220	p_{36}	319
p_{13}	204	p_{45}	211
p_{14}	317	p_{46}	176
p_{15}	370	p_{56}	242
p_{16}	422		

b Integer solution

Each line represents one circuit

path	no. of circuits	path	no. of circuits
p_{A1}	1	p_{12}	1
p_{A3}	2	p_{23}	1
p_{A4}	1	p_{34}	1
p_{A5}	2	p_{46}	1
		p_{56}	1

all other $p_{ij} = 0$

cost = £2 727 000

Illustrative example

At present two 7-substation designs and two 9-substation designs have been obtained. One of the 7-substation designs is shown in Fig. 1. Here (Fig. 1a) six 132/33 kV substations to be provided in a city to reinforce a 33 kV subtransmission network were to be supplied from a 275/132 kV supply point A. The maximum load at substations S_1, S_2, S_3, S_5 and S_6 was assumed to be 60 MVA and that at substation S_4 120 MVA.

It was also assumed that 132kV cables of 120MVA rating would be used on the proposed network and that sufficient security, allowing the possibility of circuit outage and poor load distribution between circuits, would be obtained if the relationship between load and number of circuits was as follows:

Group load S MVA	Circuits required
$S \leqslant 120$	2
$120 < S \leqslant 180$	3
$180 < S \leqslant 300$	4
$300 < S \leqslant 360$	5
$360 < S \leqslant 420$	6

Fig. 1b shows the design obtained which, together with the others so far completed, has been studied on an a.c. network analyser and found satisfactory.

Difficulties in design by linear programming

The main difficulty in the application of the method is due to the rapid increase in the number of constraint equations as the number of substations to be interconnected increases. The writing of these equations is in itself time-consuming and the preparation of a computer programme to generate the equations is at present being investigated. Possible methods of increasing the problem size solvable on a given computer are:

(1) to use Kron's 'tearing' technique
(2) to use only a 'sample' of the design equations since it has been found that about 80% of the design equations are oversatisfied
(3) to make more effective use of the computer storage by using one word length to store several elements of the matrix. This may be possible since it has been observed that the matrix elements are small integers, simple fractions, or a combination of these.

Other, less satisfactory, criteria such as minimization of total circuit length or minimization of the product of apparent power and distance can be used in network design. These do however make smaller demands on computer storage facilities.

Conclusions

It is not suggested that adoption of the technique proposed would make unnecessary the present tools of the system-design engineer—the network analyser and the digital computer as an instrument for network analysis. Nor would it necessarily lead to economies on any single reinforcement. However, the capital invested yearly in extensions to the transmission and distribution networks is so large that any method of making even a marginal saving would repay further investigation. It also seems possible that linear programming may be one means by which a certain amount of computer control of network switching and loading could be achieved.

621.316.11 : 681.142

ELECTRONICS IN ENGINEERING RESEARCH

A short article based on a Graduate and Student Section paper with the above title by J. J. Hunter, Graduate. The paper was read at Glasgow on the 13th February 1958 before the South-West Scotland Graduate and Student Section and was awarded a premium by the Council. The author is at the National Engineering Laboratory, East Kilbride.

Both digital and analogue techniques are used in modern electronic instrumentation. Digital techniques are likely to become the more important owing to their greater accuracy and circuit reliability and because their outputs are more readily put in a form for suitable presentation to the large digital computers now extensively used in research and industry.

The analogue method however is still advantageous in many cases, since a wide variety of analogue-type transducers have been devised and the output is often desired in graphical form.

These points may best be illustrated by examining some digital and analogue methods, first for some quantities that fall naturally into digital form.

Digital systems

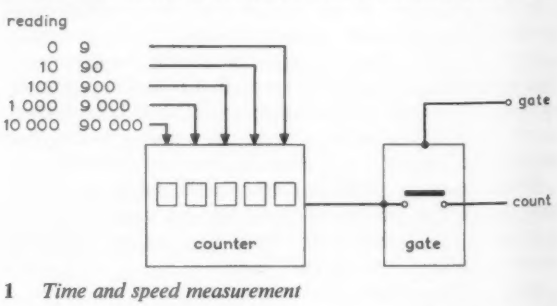
The measurement of time, and hence linear and angular speeds, can easily be carried out to an accuracy within a few parts in a million using digital methods for measurement and a quartz-crystal oscillator as a frequency standard.

Timing is accomplished simply by using the beginning and end of an event to 'gate' a standard pulse train to a counter (Fig. 1). Alternatively, as in angular-speed measurement, a standard-frequency pulse may be used to 'gate' the output from a suitable digital transducer (Fig. 2).

A fundamental limitation on digital accuracy is now seen to be that the transducer and counter discriminate only to within one count. However the output may have from 1000 to 10000 or more counts, and this is a greater accuracy than that obtainable in analogue-type output devices.

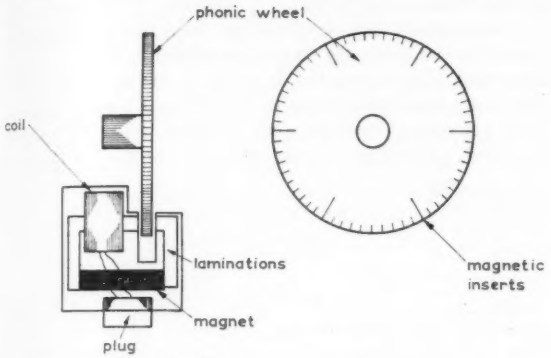
Speed control

A speed-control system making full use of digital methods has been described by Leslie in which (Fig. 3) the output from a digital transducer is compared with a standard pulse train



1 *Time and speed measurement*

in a digital frequency comparator, the output from the comparator providing an error signal to the motor controller. It may be noted that there is no steady-state error in the motor speed compared with the standard.



2 *Digital speed transducer*

If we interpose a digital divider of ratio N between the transducer and comparator, the motor is forced to rotate at a speed of N times the standard frequency.

Displacement

Linear or angular displacement can be converted to digital form by coded tracks of discs called digitizers which provide an output with a binary-number base. The principle is simple: the tracks are divided into conducting or non-conducting segments detected by brushes, or into transparent or non-transparent segments detected by photocells. An appropriate number of tracks are used with divisions and place value to suit the number of discrete levels required.

Another digital method of measuring displacement is to sum a number of small displacements. An example of this is the counting of moiré fringes in machine-tool control systems.

Analogue equipment

The basic requirements for a general-purpose analogue measuring equipment for laboratory use are:

It should accommodate as wide a variety of transducers and output devices as possible

It should have a gain/frequency characteristic, extending from direct current upwards, such as to provide accurate reproduction of the highest-speed phenomena encountered.

Basically a direct-current or -voltage representation throughout of the physical quantity is simplest. For instance rotary or linear displacement may be converted into a proportional direct voltage by using a rotary or linear potentiometer. These are important conversions, since other physical variables can often be turned into displacements.

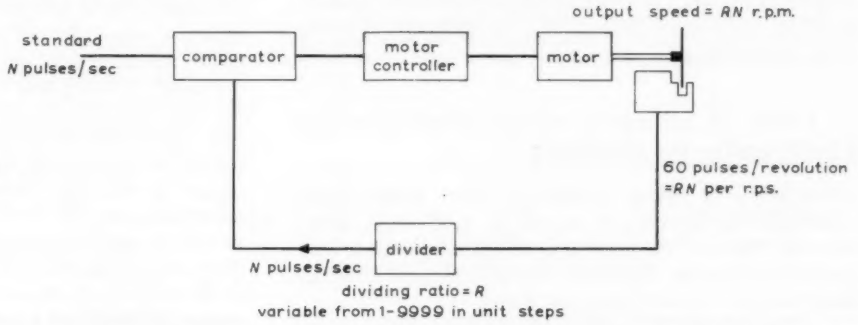
Unfortunately potentiometers are not very suitable for continuous high-speed work, while transducers composed of reactive elements, which are suitable, cannot be used in a d.c. system unless followed by an integrator. In addition, for sensitivity, power gain from the transducer signal to output is required and there are drift problems in d.c. amplifiers which are not easily overcome.

In this case an amplitude-modulated system has been chosen for general use in the laboratory, since a wide variety of suitable transducers have been devised.

Amplitude modulation

Any arrangement of resistive, inductive, or capacitive elements can be employed as a transducer where the impedance of the element can be changed by the physical variable. The conversion from physical variable to electrical signal is then a straightforward process of voltage division at the transducer, similar to that described for the d.c. system.

The circuit includes an oscillator supplying the transducer; the modulated carrier signal from the transducer is amplified and a d.c. output proportional to the physical variable recovered from the amplified signal in a demodulator. If the transducer is arranged as part of an a.c. bridge, a zero point independent of oscillator amplitude and amplifier gain can be obtained. A phase-sensitive demodulator must be employed if full use is to be made of push-pull transducers in an a.c. bridge.



3 *Speed-control system*

Accuracy

Much of the inaccuracy associated with analogue methods is due to the shortcomings of the output devices available, i.e. either lack of resolution or non-linearities. The errors can range from about 0·2 to 5% of full scale.

To increase the reading accuracy for recurrent displacements, two similar push-pull inductive displacement

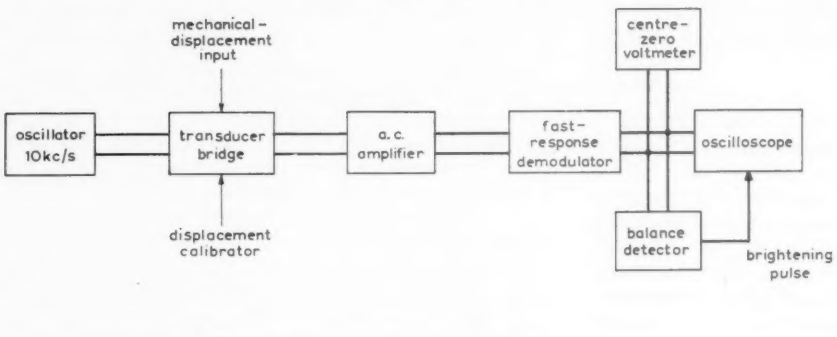
transducers are arranged in an a.c. bridge. One of these is situated in the test apparatus, while the other is in a calibrator and is set by a micrometer. The bridge is balanced when the cores of both transducers are at the same position.

The salient features of a recurrent waveform or a static position are found by adjusting the calibrator to balance the bridge at the point of interest and observing the micrometer reading. A balance marker has been devised giving an output at zero volts that can be used to brighten an oscilloscope trace as the signal passes the balance point. This measurement can be made at greatly increased gain for a particular point.

Some equipments (Fig. 4) have been developed on these lines and are being used in the laboratory for investigating mechanical high-speed phenomena.

Conclusion

It seems likely that developments in strobing techniques, essentially similar to the method described for displacement measuring, will increase the accuracy of analogue recording. Also many more types of digital transducer, allowing accurate direct conversion from physical quantities other than those described, will probably be devised. 621.317.39:621.374.32



4 *High-speed measurement*

Synopses of papers

THE following are synopses of papers published in the *Proceedings* which have not been read at Institution meetings and which have not been reviewed in the *Journal*. They are included here primarily for reference. The papers have not been published individually, as have those for reading at meetings, but reprints will be available in due course

Electricity in aircraft

A synopsis of a Review of Progress (paper 3198) entitled 'Applications of electricity in aircraft' by V. A. Higgs, B.Sc., Associate Member. The paper is published this month in Part A of the Proceedings. The author is with Associated Electrical Industries Ltd., Aircraft Equipment Group.

IN this first review of its kind it was necessary to devote some space to a historical survey. Fortunately aeronautics is a comparatively young science and the early days of flying are still within living memory; in fact many of the pioneers are still alive, and some hold responsible positions in the aircraft industry, which has grown up out of their enthusiasm and courage.

Before 1939 electrical power was used mainly for radio, lighting and heating. It was not until the Second World War that electrical power was used in aircraft to any great extent. During the war large increases in electrical power requirements were caused by an increasing use of radio, the introduction of airborne radar, and the replacement of hydraulic auxiliary power by electrical auxiliary power.

It was the introduction of airborne radar that first caused a.c. generators to be used in aircraft, and a.c. supply then became preferred for the operation of electrical flying instruments, especially those employing gyroscopes.

During the war it was found that hydraulic pipelines were far more vulnerable to enemy action than electric cables, so there was a trend to dispense with hydraulic power in favour of electrical. A complete range of electric actuators is available today, but for large power applications which have to be continually reversed, such as powered flying controls, it is preferable to use a combination of electrics and hydraulics. With this arrangement, power is distributed about the aircraft as electricity, and the moving part is operated by hydraulic power obtained from a pump driven by an electric motor.

Standard supplies

At the end of the Second World War there were no less than 36 different varieties of electrical power-supply requirement. It is now recommended that no more than the following should be recognized as standards for aircraft electrical power supplies:

320 — 1000c/s 115/200 volts 3-phase variable-frequency
400 ± 20c/s 115/200 volts 3-phase constant-frequency
28 volts direct current.

The low-voltage d.c. power system has been developed with generator units of outputs up to 400amp, either as d.c. generators or as alternators and rectifiers. There is an obvious

limitation to the use of larger units, set by the weight of cables required. The use of a.c. generators and rectifiers has led to the development of mixed systems in which some power is used as variable-frequency alternating current and some as direct current. Mixed systems are very useful when there are large electrical loads which are not sensitive to frequency—such as with de-icing or with electrical heating.

The target of the electrical engineer has always been the development of a constant-frequency power system for aircraft. This has now become practical through the development of constant-speed drives. Today there is an extensive range of electrical equipment (both a.c. and d.c.) suitable for use in aircraft; this was the subject of The Institution's 1956 convention on electrical equipment of aircraft.

High speeds and high temperatures

The immediate future will be concerned with providing improved reliability of existing basic types of equipment without increasing the weight. However, consideration is being given to aircraft capable of flying at 1500–2000m.p.h.; at speeds of 2000m.p.h. there will be new and difficult problems for accessory manufacturers. Because of the difficulty in operating hydraulic systems at high temperatures, auxiliary power will have to be electrical; the power system will almost certainly be alternating current, probably 400 volts 800c/s.

The operating temperature of some items of equipment will have to be increased to 300° or 400°C; and, as operating speeds increase still further, temperature will be the main problem. It is already possible to convert heat to electricity directly with static equipment, but at very low efficiency. Further development of this process with new materials may be the means of defeating the 'thermal thicket'.

There is undoubtedly a tremendous field of research still open to further development of aircraft electrical accessories. Those in the British electrical industry who have specialized in aircraft equipment are quite capable of meeting the challenge set by the aircraft industry. 621.311 : 629.13

Voltage stabilization by corona discharge

A synopsis of an Electronics and Communications Section paper (3174) entitled 'The corona discharge and its application to voltage stabilization' by E. Cohen and R. O. Jenkins, Ph.D., F.Inst.P. The paper will be published in Part B of the Proceedings. The authors are in the Research Laboratories of the General Electric Co. Ltd.

THE authors discuss the properties of a gas discharge which make it suitable for voltage stabilization. They describe various types of corona discharge and show that a corona discharge between a wire anode mounted axially in a cylindrical cathode is the most suitable for voltage stabilization. To obtain the required low impedance it is necessary to use hydrogen as the filling gas.

The effect of dimensions on the voltage and impedance of the discharge is discussed, and characteristics of various tubes which have been developed as corona voltage stabilizers covering a range of 350–7000 volts are presented. Finally some of the applications of such tubes and their appropriate operating conditions are given. 621.387 : 621.316.722

Dielectric properties of low-loss ceramics

A synopsis of a Measurement and Control Section paper (3223) entitled 'Determination of the dielectric properties of low-loss ceramics at Q-band frequencies' by J. M. Free, B.Sc., Student, and G. B. Walker, Ph.D., M.A., Associate Member. The paper will be published in Part B of the Proceedings. The authors were formerly in the Department of Electrical Engineering, Queen Mary College, University of London. Mr. Free is now in the Engineering Laboratory, University of Oxford, and Dr. Walker is Research Professor at the University of British Columbia, Vancouver.

ALTHOUGH the difficulties involved in the measurement of dielectric properties increase with frequency, a conventional cavity method with minor modifications has proved satisfactory at millimetre wavelengths.

A cavity of $\frac{1}{2}$in. diameter was excited in an H_{01} mode by means of coupling holes. It was found to have sufficiently low wall loss to enable the loss tangents of disc specimens of magnesium titanate and titanium dioxide ceramics to be measured. Both loss tangents were of the order of 0·0003, and the relative permittivities were 14 and 80 respectively.

Although a high degree of accuracy is not claimed, useful results can be obtained with relatively simple equipment. A convenient method of marking small frequency intervals is described. 621.317.335.3 : 621.315.612

Atmospheric radio noise at 11 Mc/s

A synopsis of an Electronics and Communications Section paper (3158) entitled 'A study of atmospheric radio noise received in a narrow bandwidth at 11 Mc/s' by C. Clarke, Associate Member. The paper will be published in Part B of the Proceedings. The author is at the Radio Research Station.

THE author describes equipment for studying atmospheric radio noise by means of continuous-film photography and by measuring the amplitude probability distributions by a pulse-counting technique. Results are given for observations in England during the summer and autumn of 1956. The observations were made over a bandwidth of 400c/s.

No simple mathematical representation of the amplitude probability distribution has been found which will fit all conditions, and a graphical presentation is suggested as a means of providing communication engineers with the required data.

The high-frequency radiation consists of a burst of quasi-continuous noise throughout the duration of the flash. This suggests that a burst-duration distribution may be a useful additional measurement in defining the interference effect of the noise. 621.391.821

OBITUARY

Obituaries of Honorary Members, Members and Companions only are published in the Journal

KENNETH OLIVER AINSLIE

Kenneth Oliver Ainslie, B.SC.(ENG.), who died at Middlesex Hospital on the 25th September 1959 after a short illness was born on the 22nd March 1916. He was educated at Eastbourne College and graduated with first-class honours in engineering at the City and Guilds College, London, in 1937. He was top of the class list and was awarded the Siemens Memorial Medal.

From 1937 to 1947 he served with Murphy Radio and was responsible for the design of communication receivers for the Navy. He joined the Mullard Research Laboratories within a few months of their inception at Salfords, Surrey, and subsequently set up the receiver section. After developing further communication equipment for the Services, he was responsible for a great diversity of projects to which he applied considerable experimental skill. He also contributed to work on television, broadcast-receiver techniques, stereophony and sound reproduction, to which his approach was typically scientific and professional.

Although very successful academically and capable of first-class theoretical work, he was primarily a practical engineer with an unrivalled feeling for mechanisms of all kinds, and there is little doubt that he was one of the most skilful receiver designers in the country. As a colleague he was generous and unselfish to an extreme degree and had a great sense of duty both to the organizations which he served and to his professional colleagues.

Outside his business activities his interests were also very diverse, and in sport (he won a public schools prize at Bisley), motoring, photography, travel and music he engaged with knowledge, skill and enthusiasm. Above all else was his interest in his home and family. He is survived by his widow and a baby daughter.

He joined The Institution as a Student in 1936 and was elected an Associate Member in 1946 and a Member in 1955. N. E. G.

JAMES LAMONT BLUE

James Lamont Blue who died on the 11th January 1960 after a long illness was born at Greenock on the 8th January 1905. Educated at Greenock High School and the Royal Technical College at Glasgow, he was an apprentice until 1924 and then a mains electrician and jointer with Greenock Corporation electricity department. In 1930 he entered the employment of Glasgow Corporation, serving in the distribution department and later transferring to Dalmarnock power station. In 1944 he was appointed a charge engineer at the Bonnybridge generating station of the Scottish Central Electric Power Co. and station superintendent in 1948.

In September 1958 he was leaving Bonnybridge to go to Yoker as station superintendent but unfortunately, owing to illness, was not able to take up duty. He was extremely interested in his work and was a strict disciplinarian, and while at times he could be a little rough with people who failed to come up to expectations, he was basically a very kindly person.

He was a prominent member of the local Toast Masters and Rotary clubs and was also very interested in, and a keen worker for, Denny Parish Church. He is survived by his widow, two daughters and a son.

He joined The Institution as an Associate Member in 1943 and was elected a Member in 1956. H. A. C.

WILLIAM DIXON

William Dixon who died after a brief illness on the 31st December 1959 was born on the 17th November 1888 at Whittingham, Northumberland, where his family had lived for generations. He was educated at Barnard Castle School and in 1905 joined C. A. Parsons as an apprentice, studying part-time at Armstrong College and at Rutherford College, Newcastle upon Tyne.

He joined Merz and McLellan at Newcastle upon Tyne in 1911 as an assistant engineer under R. W. Gregory. He volunteered immediately war broke out in 1914 and soon after his return from active service in 1919 was appointed to supervise Merz and McLellan's work in Newcastle for the State Electricity Commission of Victoria and the County of London Electric Supply Co.

After the opening of the original Barking power station in 1925 he moved to Merz and McLellan's London office with increased responsibilities, including the general supervision of work for the Central Electricity Board in the London area. In 1937 he was made a partner in the firm and returned to their Newcastle office where, after a few years, he took over the general administration and co-ordination of its work with that of the offices in the south. He also took personal responsibility to a number of clients for the work undertaken for them at home and abroad. These activities he continued to the date of his death.

His wide responsibilities took him oversea on many occasions, including a somewhat hazardous journey to America during the Second World War, and visits to South Africa and Rhodesia.

In his apprenticeship days his colleagues found in him a likeable and staunch friend. His delightfully impulsive outbursts against any form of injustice and oppression often led him into trouble, both then and in later life, but he never flinched, and to this appealing trait in his character was added a subtle and great sense of humour, always courageously shown in adversity. During the 1914–18 War, first as a despatch rider in the Royal Northumberland Fusiliers and later as a commissioned officer in the Tyne Electricals (Royal Engineers), few did as much to foster and maintain morale and a cheerful atmosphere.

He was particularly interested in rugby football and from 1918 to 1925 played for Gosforth Nomads, and his name was one to conjure with in Northumbrian and Gosforth rugby-football circles. Up to his death he was a member of Gosforth Club and of Northumberland Rugby Union, apart from which he was a keen golfer.

Undoubtedly his outstanding characteristic was his immense loyalty to his friends, which was returned, and they showed it by their large attendance at the memorial service for him in Jesmond Parish Church. He is survived by his widow, Florence, three sons and a daughter.

He joined The Institution as an Associate Member in 1917 and was elected a Member in 1938. He served on the North-Eastern Centre Committee from 1941 to 1946, being vice-chairman in 1944–45 and chairman in 1945–46. He was a member of The Institution of Mechanical Engineers, The North East Coast Institution of Engineers and Shipbuilders and The Institute of Metals and was a Fellow of The Institute of Fuel. J. R. B.

THOMAS CHARLES FINNIMORE

Thomas Charles Finnimore, M.B.E., who died on the 1st February 1960 was born in London on the 6th August 1911. At 15 years of age he started work with the Gramophone Co. and began his education as an electrical engineer by part-time National Certificate courses at Acton Technical College. He was top of his final year and simultaneously obtained the City and Guilds full technological certificate in distribution, which he later supplemented by finals in radio.

In 1932 he became a test engineer with E. K. Cole, Southend on Sea. In 1934 he joined Lissen Ltd., Edmonton, and when the amalgamation with Pye Radio took place he became chief test engineer at Cambridge.

In 1939 he joined H.M. Signal School, Portsmouth, and rapidly assumed leadership in the design of radar equipment for H.M. ships. He demonstrated one of his pieces of equipment at the Radiolocation Convention in 1946, when he presented a paper entitled 'Engineering design of shipborne gunnery radar panels', and it drew spontaneous applause for its great advance on earlier designs. He became project leader in turn of two large teams developing major radar equipment now in service. In his last year he was assistant chief scientist responsible for managing the men and money resources, where his organizing ability and drive were of great value.

'T.C.' enjoyed life: his cultural interests were wide, and his family was a happy and abiding background to the vagaries of professional life. By temperament uncompromising, he had little fatalism in his approach to life. His remarkable resistance to a disease which he knew to be judged fatal was a humbling example of his stoic character. He is survived by his widow and two sons.

He joined The Institution as a Student in 1931 and was elected

a Graduate in 1933, an Associate Member in 1939 and a Member in 1947. He was appointed a Member of the Order of the British Empire in 1946. W. D. M.

ARTHUR GORDON MEW FRANKLIN

Arthur Gordon Mew Franklin who died on the 26th October 1959 was born on the 1st June 1885 and was one of the pioneers in the manufacture of radio valves on a mass-production scale.

The son of James Franklin, a British Consul in Norway, he received his general education in Norway and at Old College, Windermere, and his engineering education at the Victoria University of Manchester. He joined the British Westinghouse Electric and Manufacturing Co. in 1906 as a college apprentice and later represented them in Norway, at first as an engineer of the Norwegian branch of the company and later as managing director of Vickers Norsk Elektroteknisk Aktieselscab. He returned to England in 1924 and became general manager of Cosmos Lamp Works (subsequently the Cosmos Manufacturing Co.), which at that time manufactured electric lamps, heaters and cookers. Shortly after his appointment the company embarked on the manufacture of radio valves which, together with television cathode-ray tubes introduced at a later date, were to become the sole business of the company. He retired in 1942.

To his colleagues and staff he was a kind and considerate associate; he had a sunny temperament which helped them (and him) to cope with the vagaries of dull-emitter valve manufacture which were experienced on so lavish a scale in the early years of the industry.

In his youth he was a keen yachtsman and in his school-days in this sport he and a friend won the King's Cup (Norway) for schoolboys three years in succession. In his later years his recreations were badminton and gardening.

He joined The Institution as a Student in 1908 and was elected an Associate Member in 1912 and a Member in 1929. E. Y. R.

WALTER LAWSON

Walter Lawson who was born on the 28th May 1875 died on the 28th October 1959. He was educated at the Merchant Venturers' School and Technical College, Bristol, and served a four-year apprenticeship with P. Jolin and Co., Bristol.

In 1895 he joined the teaching staff of the University College of Wales, Aberystwyth, where he remained three years. He then gained meter experience at Chamberlain and Hookham, Birmingham, and in 1900 joined the electric supply department of Birmingham Corporation and became head of the meter and motor department. For a number of years up to the time of his retirement in 1937 he was special technical assistant to the city electrical engineer.

Scrupulously fair, he was highly esteemed by all who worked under him. In his younger days he took an active part in amateur theatricals and lawn tennis. He was interested in reading and photography. A devoted husband, he was happily married to a very charming wife who survives him.

He joined The Institution as an Associate Member in 1913 and was elected a Member in 1924. He served on the South Midland Centre Committee from 1920 to 1927, being vice-chairman from 1922 to 1924 and chairman in 1924–25. He was chairman of the Meter and Instrument Section in 1933–34. His papers entitled 'Defects in electricity meters' and 'The rotor bearings of electricity meters' were published in the *Journal* in 1920 and 1929 respectively. A. E. T.

JAMES NELSON

James Nelson who died on the 31st January 1960 was a native of Bristol where he was born on the 4th June 1881. He was educated at Merchant Venturers' Technical College, Bristol, and received practical training with Pitcher and Sons and with T. G. Wright, Bristol.

He joined British Insulated and Helsby Cables in 1903, and from that date until 1929, with the exception of a period of war service, he was engaged on the design and construction of cable and overhead-line systems. He joined the Royal Navy in 1916, and after a period of training in H.M.S. *Vernon* at Portsmouth he was appointed to H.M.S. *Tiger* and then to H.M.S. *Renown* as an electrical officer. After the armistice he returned to H.M.S. *Vernon* as a staff officer until 1920 and, on being placed on the reserve attached to R.N.V.R. Mersey Division, returned to his former company.

On the formation of the Central Electricity Board he left British Insulated Cables to join the Board as a transmission engineer and was engaged in the Midlands until his retirement in 1945. Retirement did not come to him easily, and for eight years he returned to British Insulated in a capacity which enabled him to keep in touch with former colleagues and interests.

He was a man who found time for many other interests and, despite his quiet disposition, entered into these with great enthusiasm. His imagination was fired by the possibilities which lay in wireless telephony, and in the early days of broadcasting he became an enthusiastic experimenter and constructor. He was also a keen motorist, by which he was able to satisfy both his engineering outlook and his love of beauty in landscape and architecture. This latter interest led him to take up photography and he became a Fellow of the Royal Photographic Society. Although this pursuit remained a hobby, he nevertheless reached in it near-professional standards and became responsible in a semi-official way for photographing many of our historic buildings. He joined the Batti-Wallahs Society in 1946 and served for a time on the committee.

He joined The Institution as an Associate Member in 1919 and was elected a Member in 1924. D. T. H.

WILLIAM JOSEPH ROBERTSON

William Joseph Robertson who died on the 29th March 1959 was born in Denbigh on the 13th August 1884. He was educated at Llangollen Grammar School and received his engineering training with Whiley and Co., Liverpool, and his technical training at Liverpool Technical College and at Regent Street Polytechnic.

In 1905 he joined the electrical staff of the Central London Railway to gain further experience and in 1911 transferred to the Great Western Railway on the maintenance of electrical equipment.

In 1914 he was engaged by British Thomson-Houston as a supervisor on railway electrification contracts in London and in 1918 became district electrical engineer for N.E. England on the construction of power station, railway and industrial plant. In 1923 he was appointed district engineer for London and Southern England in a similar capacity and in 1928 electrical constructional superintendent at Rugby.

On the introduction of talking films he joined the Radio Corporation of America in 1928 as chief of installation and maintenance of sound-reproducer equipment in Great Britain. In 1938 he joined Central London Electricity as construction engineer and later became supplies officer on the staff of the Engineer-in-Chief. During the Second World War he was lent to the Air Ministry for progressing and supervising construction work on coastal radar stations and rendered yeoman service during a critical period.

He was a man of lovable nature: a born leader of men, in whom he inspired complete confidence. He had a wonderful good-humour and was greatly respected by all who knew him. His principal hobby was fly-fishing in his beloved North Wales. He is survived by his widow and son.

He joined The Institution as an Associate Member in 1921 and was elected a Member in 1928. J. W. L.

JACK HECTOR STORRAR

Jack Hector Storrar who was born on the 22nd July 1900 died on the 5th November 1959 after a short illness.

He received his technical education part-time at Wolverhampton and Staffordshire Technical College and received practical experience with Rees Roturbo Manufacturing Co., Wolverhampton, where he eventually became works manager and supervised the installation of the company's machinery in Belgium and Russia.

He joined the Calico Printers' Association in 1935 as works engineer at the Birch Vale works. In 1939 he became deputy chief engineer at their head office and was appointed chief engineer in 1947, an appointment which frequently took him abroad.

His work was sound and thorough, and his judgment was highly respected by his associates. He joined the Royal Flying Corps towards the end of the First World War and was undergoing training as a pilot at its conclusion. He was an enthusiastic member of the Hazel Grove Golf Club. He is survived by his widow.

He joined The Institution as a Student in 1925 and was elected a Graduate in 1926, an Associate Member in 1928 and a Member in 1950. He was a Member of The Institution of Mechanical Engineers. G. B. A.

PAPERS AND MONOGRAPHS

published individually this month

Papers accepted for reading at meetings and monographs are first published individually and are republished later in the Proceedings of The Institution; as soon as the separates are available they are described in this feature. The papers are supplied free of charge; the price of a monograph is 2s.

In addition reprints of papers read at meetings including the discussions thereon and of papers not read at meetings become available, price 2s., within two months of their appearance in the Proceedings.

Applications quoting the serial number of the paper, monograph or reprint as well as the author's name and accompanied by a remittance where appropriate should be addressed to the Secretary of The Institution. For convenience, books of five vouchers for this purpose can be obtained in advance, price 10s.

Those who obtain a copy of a paper published individually are urged—if they do not take the Part of the Proceedings in which it will be republished—to apply in due course for a reprint as this is the final and correct version and includes the discussion.

PAPERS

Planning and installation of the sound-broadcasting headquarters for the B.B.C.'s Overseas and European Services *Paper* 3213E: *Part B*

F. AXON, D.C.M., *and* O. H. BARRON, M.B.E., B.SC.

FOLLOWING a brief history of the B.B.C.'s External Services, there is an outline of the reasons for the present form of centralization at Bush House. The method of programme building is considered and the studio and recording facilities are detailed. The equipment in the control room and other technical areas is described. Installation problems are discussed and some notes are given on practical experience with the installation in service.

To be read on the 2nd May 1960

The resistance of sheet insulation to surface discharges *Paper* 3250M: *Part A*

J. H. MASON, PH.D.

INVESTIGATIONS show that a satisfactory classification of insulating materials with respect to their resistance to deterioration and breakdown by surface discharges in air is given by 'time to breakdown' tests using simple rod and plate electrodes. It is necessary to circulate dry air over specimens to avoid the formation of semiconducting films, and comparison should be made only between specimens of similar thickness. The discharge resistance of most materials is reduced by increase in ambient temperature or by the application of mechanical strain. Results of tests on thin films and sheets of several polymers and on both glass and paper laminates of 1–3 mm thickness are reported.

Recommendations for standard tests for comparing the discharge resistances of materials are given in the appendixes.

To be read on the 12th May 1960

MONOGRAPHS

A calculation of switching functions as a means of minimizing error in an on–off control system *Monograph* 370M

R. F. BROWN, B.ENG.

SELF-optimization of control systems is becoming a practical proposition through new developments in the electronics field, notably in digital-computer techniques. To this end, the author, after discussing some essential basic concepts, proposes an adaptive switching function as an on–off controller.

Results are given for repeated application of step and ramp inputs to a mathematical model of an ideal servomechanism, set up on a Deuce digital computer. The results neglect relay imperfections; they are preliminary in nature and are intended to evoke further research.

Eddy-current effects in rectangular ferromagnetic rods *Monograph* 371M

E. W. LEE, B.SC., PH.D.

EXPRESSIONS are obtained for the eddy-current distribution and the resulting loss angle for an infinitely long ferromagnetic rod of rectangular cross-section containing a number of domains magnetized parallel and anti-parallel to the axis of the rod and separated by domain walls running perpendicular to the long edge of the cross-section.

Results are expressed in terms of the ratio of the lengths of the sides of the rod and the number of walls. Two cases are considered—the low-frequency limit in which the domain walls remain plane and the more general case in which the wall becomes bowed because of eddy-current screening effects.

Investigation of an electrical non-destructive method of measuring the depth of surface hardness in flame-hardened steels *Monograph* 372M

J. A. BETTS, B.SC., PH.D., *and* J. P. NEWSOME, M.SC.

AT the present time there exist no established, non-destructive methods for the measurement of depth of hardness in surface-hardened steels which are independent of the effects of chemical composition and quench procedure. Electrical non-destructive techniques depend on changes in the electrical and magnetic properties of steel which occur when it is hardened.

The electrical method investigated by the authors was an a.c. one, based on the measurement of the complex impedance of a search coil magnetically coupled to the test surface. Distinctly favourable results were obtained, and the paper is concerned with the theoretical and practical aspects of the procedure.

Perturbation theory of resonant cavities *Monograph* 373E

R. A. WALDRON, M.A.

A DETAILED derivation is given of the perturbation formula for the frequency shift on introducing a sample of ferrite or dielectric material into a resonant cavity. The purpose of this is to make clear what assumptions are involved in the derivation; it is necessary to appreciate what these assumptions are in order to design accurate experiments.

Two-terminal *RC* networks and theoretically related topics *Monograph* 374M

O. P. D. CUTTERIDGE, M.SC.(ENG.), PH.D.

A DERIVATION is given of the properties of the principal minors of successive orders of the nodal determinant of a lumped linear *RC* network, particular attention being paid to the question of multiple zeros of the various minors.

The remainder of the paper is devoted to the study of a certain continued-fraction expansion which is shown to be of special use in connection with 2-terminal *RC* networks, stability and related problems; new canonical forms for a Hurwitz polynomial are derived with its aid. Determinantal expressions for the continued-fraction coefficients are used to obtain some new forms of the stability criteria.

Brush contact losses due to load and parasitic currents in polyphase commutator motors *Monograph* 375U

O. E. MAINER, M.SC.TECH.

AFTER brief reference to present methods of measurement, the interdependence of the brush losses due to load and parasitic currents is discussed, and the need for measuring them simultaneously is argued. Owing to the impossibility of doing this satisfactorily on a motor, an apparatus for simulating brush parasitic currents has been devised, and test data obtained with this equipment are used to establish the argument. The effects of rotor power factor and speed on the losses are also considered and established experimentally.

Finally, a new test is described by means of which the total rotor I^2R losses of a polyphase commutator motor can be measured with reasonable accuracy. Curves obtained by this method of test using plain and sandwich brushes show the dependence of these losses on the coil e.m.f. between segments.

Calculation of the current in non-linear surge-current-generator circuits *Monograph* 376S

T. F. MONAHAN, B.SC.

SURGE-current generators are used to test non-linear resistors and surge diverters. Although the circuit is basically very simple, it is possible to calculate the surge current only by numerical solutions of the differential equation for particular values of the parameters.

The author gives the results of such calculations made at Manchester University on the differential analyser and the electronic computer. The application of the results to certain practical problems is discussed.

Transients in cylindrical antennae *Monograph* 377E

H. J. SCHMITT

THE transient response of the radiation field of a driven cylindrical antenna is investigated for the particular case of a step-function excitation. The theoretical analysis makes use of Fourier's theorem to express the response as an integral over the response to all individual frequency components. The response, as a function of time, displays damped oscillations with a frequency determined by the first resonance frequency of the antenna. The response of the same antenna used as a receiver in a transient plane-wave field is shown to be related to the radiation response by a simple integration process.

By proper loading of the dipole, transient times of the order of the time needed for a wave to travel along the dipole axis can be obtained. An experimental investigation is described in which the reception of a transient field due to a shock-excited distant transmitter is observed.

Aldermaston losses and gains

AN apparatus known as Oswald, used in early work on controlled thermonuclear reactions, is now on view at the Science Museum, London, on permanent loan from the Atomic Weapons Research Establishment, Aldermaston.

Oswald consists basically of a condenser bank and switchgear capable of delivering an extremely heavy current in a very short time to a straight quartz discharge tube containing a gas under low pressure. Electrical energy was driven through the gas in the discharge tube as rapidly as possible so that a temperature of several million degrees could be reached before cooling processes and instabilities could operate.

The gas was heated by magnetic compression which required a rapid rate of rise of the current. Originally the condenser banks were discharged by a single switch, which limited this rate of rise, but a considerable experimental advance was made by using 144 spark-gap switches in parallel, all operating within a few thousand millionths of a second.

When neutrons were produced by a gas discharge in Oswald in February 1957, the first time this had been achieved in Britain, a temperature of about one million degrees Celsius was reached.

Rapid compression heating is now being studied with multi-switch banks in many nuclear research laboratories throughout the world. The largest of these devices in the United Kingdom is known as Maggie, at the A.W.R.E. This is capable of providing a current with a rate of rise of 5×10^{12} amp/sec, or about four times the rate of rise for Oswald.

A new research reactor, Herald, started operation on the 29th February 1960 at the A.W.R.E., Aldermaston, where it will be used for nuclear research work requiring intense neutron beams and for irradiation-damage studies on reactor materials.

It is a light-water-moderated and -cooled tank-type thermal reactor designed to operate at 5 MW continuously. The core of the reactor is in the form of thin plates of enriched uranium–aluminium alloy suitably spaced in water. A high flux density of thermal and fast neutrons of the order of 10^{14} neutrons/cm^2 will be achieved.

PROGRAMMED FORGING OPERATION

COMPLETELY automatic forging of steel by pre-calculated programme was recently demonstrated in the experimental forge of the British Iron and Steel Research Association at Sheffield. This is believed to be the first instance in any country.

A precision-controlled 200-ton press is interlocked with a fast, remote-controlled experimental manipulator capable of longitudinal, rotational and lifting movements, and electric controls developed for both press and manipulator ensure fast, accurate operation and synchronize the movements of the two machines.

The press and manipulator are controlled during forging by a programme-control unit on which every detail of the schedule of forging operations can be set up, including the upper and lower limit of the squeeze for every pass, the selection of manipulator feed between strokes, and the storage of the manipulation necessary between passes. The control unit signals instructions in the appropriate sequence.

The finished forging in some respects exceeds the best current industrial standards as regards dimensional precision, and the job is accomplished twice as fast as the best skilled forging crew would be capable of doing it. Even faster working will shortly be practicable.

The forging schedule for the demonstration was calculated in advance, from a theory of the change in shape during forging which had been worked out in the laboratory.

Many firms are at present planning to re-equip their forges, in some cases to replace machines dating back to the First World War, and there are now probably more forging presses on order in this country than at any previous time. This development of automatic working therefore offers the forging industry a great opportunity to place itself ahead of foreign competition.

TECHNICAL PUBLICATIONS

FURTHER information and copies of the publication can be obtained from the organizations concerned except where otherwise stated

BRITISH BROADCASTING CORPORATION

B.B.C. handbook 1960. London, 1960. 6s.

AS well as details of the B.B.C. organization, this year's edition includes a brief review of research and development being carried out on satellite transmitters, loudspeakers and microphones, control and testing equipment, studio design, transmission of news film by transatlantic cable, colour television, and stereophonic broadcasting.

Monograph no. 28 **Programme switching, control, and monitoring in sound broadcasting** by R. D. Petrie and J. C. Taylor. London, 1960. 5s.

THE authors discuss factors influencing the choice of efficient and economical switching systems. Designs suitable for the type of traffic occurring in the sound-broadcasting system of the B.B.C. are described.

BRITISH STANDARDS INSTITUTION

PD 3542 **The operation of a company standards department** London, 1959. 3s.

THIS booklet, intended as a guide to a person setting up a standards department within his organization, describes the basic tools for the job, dealing with the functions of such a department, variety reduction, and the preparation and publication of internal standards.

ELECTRICAL DEVELOPMENT ASSOCIATION

Electricity and problems of animal environmental control by D. W. B. Sainsbury. London, 1959. gratis

THE author, who is at the School of Veterinary Medicine, University of Cambridge, defines the two main types of animal housing and discusses temperature and ventilation requirements, hot-weather problems, etc.

INTERNATIONAL ELECTROTECHNICAL COMMISSION

Publication 45 **Recommendations for steam turbines. Second edition.** Part 1: Specification. Geneva, 1958. 8 Sw.fr.* (Russian/English)

THIS revision of the 1931 edition amplifies many items in the light of developments in unit output, steam pressure and steam temperature, and contains a table of ratings covering a wide range with specified steam characteristics.

Publication 50(40) **International electrotechnical vocabulary. Second edition.** Group 40: Electro-heating applications. Geneva, 1960. 8 Sw.fr.*

THIS contains 138 terms and definitions in French and English, together with the equivalent terms in German, Spanish, Italian, Dutch, Polish and Swedish. It includes furnaces, welding apparatus, and space-heating and cooking equipment. Eight indexes are provided.

Publication 72–1 **Recommendations for the dimensions and output ratings of electric motors. Third edition.** Part 1—Foot-mounted induction motors with shaft heights between 56 and 315 millimetres (2⅛ and 12½ inches). Geneva, 1959. 6 Sw.fr.* (French/English)

THE recommendations at present relate only to foot-mounted a.c. induction motors for up to 600 volts 50–60c/s, and also illustrate letter symbols for standard dimensions.

Publication 102 **Rules for the electric transmission of vehicles with Diesel engines (main d.c. motors and generators).** Geneva, 1958. 7.50 Sw.fr.* (Russian/English)

PRELIMINARY sections deal with general definitions and ratings. The main part of the recommendations covers individual tests on machines, including temperature-rise, overspeed, high-voltage tests, etc.

Publication 110 **Recommendations for power capacitors for frequencies between 100 and 20000 Hz (c/s).** Geneva, 1959. 6 Sw.fr.* (French/English)

SAFETY requirements and standards for performance, testing and rating are formulated and a guide to installation and testing is given. Definitions are included.

Publication 112 **Recommended method for determining the comparative tracking index of solid insulating materials under moist conditions.** Geneva, 1959. 6 Sw.fr.* (French/English)

THE test is to indicate the relative behaviour of solid electrical insulating materials with regard to their susceptibility to surface tracking when exposed, under electric stress, to water and other contaminants from the surroundings. It is especially suitable for synthetic-resin mouldings.

ORGANISATION FOR EUROPEAN ECONOMIC CO-OPERATION

Towards a new energy pattern in Europe. Paris, 1960. n.p.

THIS is a report of the Energy Advisory Commission set up in 1956 to keep energy problems under survey. Prospective energy requirements and supplies of Western Europe are reassessed, and economic and political problems are examined. Attention is directed to changes in the coal situation.

PERGAMON PRESS

U.S.S.R. patents and inventions. Vol. 1, Nos. 1/2. Oxford, 1959

THE Russian *Biulleten' izobretenii* is published 24 times a year and this new English translation is published monthly to contain the abstracts from two Russian issues. The complete translation costs £50 p.a., but subscriptions to individual sections are accepted at lower annual rates. For example, the annual subscriptions for Electrical and mechanical engineering, Electronics, and Measuring instruments are £15 each; the sections on Fuels, furnaces and prime movers, and Light and precision engineering cost £10 each.

SOCIETY FOR THE HISTORY OF TECHNOLOGY

Technology and culture Vol. 1, No. 1, winter 1959†

THIS new quarterly includes general articles dealing with the relations between technology, society and culture as well as more specialized ones on the history of technological processes and devices, book reviews and bibliographies. The annual subscription is $7.35 (outside the United States and Canada); single numbers cost $2.00. The first number contains articles on Ideas, history and technology, Technology and social change, and What is a railway?

* Obtainable from the I.E.C. Central Office, 1 rue de Varembé, Geneva, Switzerland

† Published by the Wayne State University Press, Detroit 2, Michigan, U.S.A.

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

AERE–M522 **A note on the production of a specified magnetic field by a cylindrical coil configuration of variable depth** by E. W. Laing and S. J. Roberts. Harwell, 1959. 3s.*

THE method described produces any specified magnetic field on the axis of the cylinder to a high degree of accuracy. Programmes have been written for the Mercury computer which calculate coil depths and the magnetic field on and off the axis of the cylinder. It is applicable to mirror machines for experiments with high-temperature plasmas.

AERE–R2924 **The measurement of neutron dose** by A. B. Clare. Harwell, 1959. 4s. 6d.*

PHYSICAL (as opposed to biological) data used to derive the maximum permissible neutron flux are summarized, and problems which arise in field instrumentation designed to measure the neutron dose are surveyed. Special problems associated with particle accelerators and criticality accidents are considered.

AERE–R3043 **The electromagnetic separation of plutonium isotopes: operational experience in 1957** by J. H. Freeman, K. J. Hill and M. L. Smith. Harwell, 1959. 9s.*

THE report summarizes the experience gained during the first year's operations on the isotopic separation of plutonium in Hermes, an electromagnetic separator of the 90° sector type. Details are given of the recovery of unseparated plutonium residues, cleaning processes and chemical and health-physics problems.

AERE–R3088 **Stabilized pinch configurations** by J. D. Jukes. Harwell, 1959. 2s. 6d.*

SUYDAM's theory has been applied to determine the magnetic-field configurations needed to stabilize certain radial pressure distributions in a linear pinched plasma against helical perturbations. Results confirm the stability of a pinch in which the axial component B_z of the field tends to reverse with increasing radius, and also the so-called 'unpinch' in which B_z initially increases outwards.

AERE–R3094 **The deposition of fission products from distant nuclear test explosions: results to mid-1959** by R. N. Crooks, R. G. D. Osmond, M. J. Owers and Miss E. M. R. Fisher. Harwell, 1959. 1s. 9d.*

RAINWATER samples collected at seven stations in the United Kingdom and at 18 stations elsewhere are analysed for content of strontium 89, strontium 90 and caesium 137.

AERE–R3126 **7GeV proton synchrotron magnet power supply voltage waveforms** by J. V. Smith. Harwell, 1959. 4s.*

POWER-SUPPLY output-voltage waveforms have been calculated for various critical operating conditions and for three possible rectifier circuits. It is shown that one particular circuit has minimum ripple components in all conditions of operation.

AERE–R3161 **A torus for the arc-testing of materials** by J. T. Maskrey and R. W. Barnfield. Harwell, 1959. 5s.*

THE authors describe a small toroidal discharge tube constructed to obtain information about the mechanism of initiation of unipolar arcs between a metallic wall and a plasma.

UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE

Bibliographical index of works published on hydro-electric plant construction—Vol. 2. Geneva, 1959. 2s. 6d.†

THE first volume of this index was published in November 1957 and contains references to information on Czechoslovakia, the Federal Republic of Germany, Finland, France, the United Kingdom and the United States. This volume incorporates references to information in the original languages communicated to the Secretariat by Belgium, Italy, Switzerland and the U.S.S.R. A comprehensive index of references, by subject, covered in the two volumes is included.

Developments in the situation of Europe's electric power supply industry during the post-war period. Geneva, 1959. 10s. 6d.†

THE report includes chapters on the consumption of electric power (including world figures), trends in electric power production, transmission equipment, and the problems of international transfer and exchange of electric power.

UNITED STATES DEPARTMENT OF COMMERCE OFFICE OF TECHNICAL SERVICES

AEC Research and development report HW–59323 **Carbon arc image furnace and microscope for studies at high temperatures.** 1959. $1.00

THE equipment described is for microscopy studies at up to 2200°C of ceramic fuel-element materials.

AEC Research and development report KAPL–2006 **Transistorized log-period amplifier.** 1959. $0.75

A LOGARITHMIC and a period amplifier as used in nuclear-reactor instrumentation are combined in one small unit by means of transistor circuits.

NRL Report 5316 **Salvage of flooded electrical equipment.** 1959. $0.75

AN integrated procedure for field salvage of salt-water-flooded and oil-fouled electrical equipment is outlined.

PB 151 629 **Optimum frequencies for outer space communication.** 1958. $1.00

TECHNICAL factors affecting outer-space communication are summarized as a basis for selecting frequencies for communication between Earth and a space vehicle or for communication between outer-space vehicles.

PB 151 644 **Evaluation of limitations and applicability of solid-state amplifiers and remote viewing systems for high voltage fluoroscopy.** 1958. $1.75

THE investigations described were concerned with theoretical limitations of remote-viewing X-ray intensification systems for industrial applications up to 2 MeV.

PB 151 749 **Properties of ferrites and their applications to microwave systems.** 1959. $1.50

THE report summarizes the ferrite development programme at the Diamond Ordnance Fuze Laboratories.

WADC Technical report 57–290 **Miniaturized, high-frequency inductors for airborne applications.** 1958. $2.25

THE report describes further development of the helical-resonator approach to miniaturization by the inclusion of high-permeability magnetic-core materials for frequencies in the region of a few megacycles per second. Air-cored helical resonators for up to 1 Gc/s are also discussed.

WADC Technical report 58–683 **Effects of high energy, high intensity electromagnetic radiation on organic liquids.** 1959. $1.25

IN order to investigate modes of breakdown of organic liquids, such as insulating and hydraulic fluids, lubricants, etc., exposed to radiation, a number of analogous compounds were studied.

* Available from H.M. Stationery Office, York House, Kingsway, London W.C.2

† Obtainable from the Sales Section, European Office of the United Nations, Palais des Nations, Geneva, Switzerland

SOME RECENT BOOKS

TRANSFORMERS FOR THE ELECTRIC POWER INDUSTRY

R. L. BEAN, N. CHACKAN, Jun., H. R. MOORE and E. C. WENTZ

McGRAW-HILL. 1959. 409 PP. £4 17S.

AS the authors are working in the United States, this volume is written around American practice and frequently refers to ASA Standard C.57 'Power transformers'. The preface states it 'is not written for the transformer specialist' but for engineers operating power systems; nevertheless, it collects together much basic theory useful to designers. Throughout the text are spread bibliographies of specialized technical papers embodying the latest advanced views. Most of these references, but not all, are to the *Transactions of the American Institute of Electrical Engineers*. Several refer to well known British engineers.

Chapter 3 is a good review of insulation problems. Chapters 4–8 inclusive deal with the construction and calculation of the losses, forces and temperature rise in the magnetic circuit and windings. Chapter 9 discusses the relations between loading and useful life which underlie the ASA C.57.92 Guides for Loading. Thermal protective devices used in America are described in chapter 10, which also surveys maintenance problems, detection of faults and selection of lightning arresters, i.e. surge diverters.

A useful review of zero sequence impedance is given in chapter 11 'Transformer connection'. The purpose of chapter 13 'Transformer testing' is stated to be the presentation of the philosophy and theory behind the ASA Test Code C.57.12–90. Cost capitalization of losses and the economics of loading relative to rating are considered in chapter 14.

The book is easy to read and should appeal to all who wish to understand the background of modern design practice, for fundamental principles apply everywhere even though the varying operating conditions may result in slight differences in inspection and acceptance standards.

FREQUENCY RESPONSE FOR PROCESS CONTROL

W. I. CALDWELL, G. A. COON and L. M. ZOSS (*Editors*)

McGRAW-HILL. 1959. 395 PP. £4 9S.

IT seems odd when a review very properly appears here of a book which contains nothing more electrical than a brief mention of a thermocouple. It could have a subtitle 'a servo engineer looks at process control' and one may agree straight away that it is quite a penetrating look. The editors make the standard claim that no satisfactory study of this sort existed before theirs, but on this occasion they seem to be justified.

As often with works of transatlantic origin the introductory material is easy going, no serious intellectual effort being required in the first 90 pages. From this point on we get the basic theory of automatic control with a very distinctive process-control bias—in this the contributors show commendable originality. In their frequency plots, in addition to the normal they use what they call 'damped' characteristics leading to systems of specified damping, following an idea due to Ream whose contribution is acknowledged (they get full marks for their discrimination and the international breadth of their reading).

One curious point is that, although 100 pages are devoted to aspects of controllers and their various frequency characteristics, at no point is the physical form of the devices mentioned. Consequently the all-important phase of analysis, namely formulating the differential equation from the physical mechanism, is not dealt with; and this in the reviewer's experience is where most of the trouble starts. However it would be churlish to make too much of this bee in a bonnet, particularly as the final 100 pages contain three very good practical examples of the application of automatic control to process control.

The volume is a real contribution to the unification of the field of automatic control in that it makes a sympathetic application of frequency-response methods (devised largely in connection with servomechanisms) to process control. It is certainly the most original attempt to date and shows real understanding of the problems of process control, which are in many ways more demanding than those that arise in relation to positional servomechanisms. Increasing numbers of members interested in automatic control are going to find themselves drawn into contact with process control, and when they do they could hardly do better than consult this publication.

SCIENCE IN INDUSTRY

C. F. CARTER and B. R. WILLIAMS

LONDON: OXFORD UNIVERSITY PRESS. 1959. 186 PP. 21S.

THIS is the third of a series of reports written for the Science and Industry Committee set up by the British Association, the Royal Society of Arts and the Nuffield Foundation. The first two, 'Industry and technical progress' (reviewed in October 1957 *Journal*, p. 538) and 'Investment in innovation' (reviewed in December 1958 *Journal*, p. 678), surveyed the factors which affect the rate of application of new scientific ideas in British industry. The present volume is again based on research in the field and contains suggestions for policy and action (by industry in part 1 and by Government in part 2) which may assist in the fruitful application of science.

If there is one criticism that can be made it is that the authors do not suggest how backward industrialists and lethargic Government departments might be encouraged to read it. And it is to be feared that it will only be read by those who already are amenable to or apply most of its valuable suggestions. It is an excellent work and the authors and the committee are to be complimented on its production. There is so much that is good that it is difficult for a reviewer to pick out points in particular.

The importance is stressed of the scientist in management if the receptiveness of management is to be improved. 'If

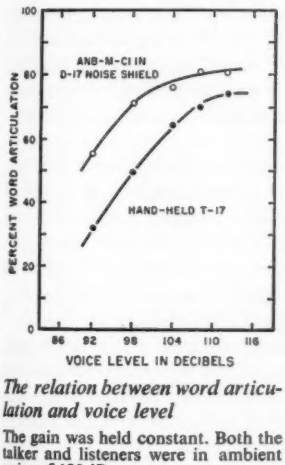
scientists are regarded as a peculiar race, not part of the social system of the company, they may be effective as receivers of ideas but not as transmitters to those in authority.' Again 'research projects should be chosen by competent scientists who appreciate the production, selling and financial problems of the firm or (if such scientists do not exist) by a small committee which combines these various qualities'.

There is much useful comment on research and its management, including some strong criticism of country houses used for research. Constructive thoughts are given on innovation and the smaller firm. The communication of ideas is among many other subjects discussed. The last chapter contains an analytical table of contents for those who wish to find their way quickly to the main suggestions. The table provides a useful check list and summary and there will be few engineers who could not profit by reading this by itself. The book, which is well printed and produced, can be highly recommended.

RESEARCH TECHNIQUES IN HUMAN ENGINEERING

A. CHAPANIS

BALTIMORE: JOHNS HOPKINS PRESS. 1959. 316 PP. $6



The relation between word articulation and voice level

The gain was held constant. Both the talker and listeners were in ambient noise of 120dB

THE author explains human engineering as applying to that branch of modern technology which deals with ways of designing machines, operations and work environment so that they match human capacities and limitations. This area of knowledge has also been described as ergonomics, and much information on it has been produced of late.

It is very difficult to dissociate the techniques required in human engineering from those applied to work study, and it is probably for this reason that many of the sections of this book discuss the methods which are available for conducting a general investigation.

For instance chapter 2, which is entitled 'The methods of direct observation', examines at some length the charting techniques which are well known to work-study practitioners. Chapter 4 on 'Statistical methods' again is an outline of techniques which can be applied in many spheres. Chapter 5 considers 'The experimental method' and does give some useful pointers in the application of techniques to human engineering. The sections on 'Psychological methods' and 'Articulation-testing methods' are interesting to the engineer who may not have encountered the details of these techniques during his normal course of study.

The author is to be congratulated on the introduction; this is very succinct and will form a good starting-point for those readers to whom the fields of application of human engineering are little known.

To summarize: students will find the volume very useful in the study of experimental methods which are not strictly applicable to the topic of human engineering. Practising engineers may find it a useful reference work, but they may feel somewhat disappointed that they do not obtain an over-all appreciation of the problems involved in this field.

PROGRAMMING PROGRAMME FOR THE BESM COMPUTER

A. P. ERSHOV

LONDON: PERGAMON PRESS. 1959. 158 PP. £3

THE 'programming programme' is a simplified scheme for preparing programmes for this Russian digital computer. The description of the scheme from the user's point of view is apparently not intended to be sufficiently full to constitute a user's handbook, nor is there mention of working speeds.

The book is however of interest in two respects: as one of the few available records of Russian progress in this field; and as one of the first descriptions of the fundamental concepts and the inner arrangement and logic of a simplified scheme. It is therefore primarily of value to those interested in basic techniques of programming, rather than to the engineer who wishes to use a computer.

There is a useful programmer's description of the BESM computer, which corresponds to other medium-sized machines of the past three or four years.

PROGRESS IN SEMICONDUCTORS—Vol. 4

A. F. GIBSON, F. A. KRÖGER and R. E. BURGESS (*Editors*)

LONDON: HEYWOOD. 1960. 292 PP. £3 3S.

THIS is the fourth in a series which has established itself as an important aid to those engaged in research on semiconductors. The amount of published work in this field is so large that one volume can attempt to review only certain aspects. The topics of the present publication are: negative effective masses in semiconductors; oxidation phenomena on germanium surfaces; theory of avalanche multiplication in non-polar semiconductors; internal field emission; noise in semiconductors; electrical effects of dislocations in semiconductors; dielectric properties of solids in relation to imperfections; and non-crystalline semiconductors. The authors, all of whom are internationally known experts, are drawn from six different countries.

Though some of the above subjects may appear to be very specialized, the authors have been able to draw on a wealth of published material, and the articles average nearly 100 references each, several having many more. The standard of writing and presentation is uniformly high but the articles are written primarily for the specialist, and the reader with a general but not specialized knowledge of semiconductors will find some of the text heavy, though rewarding, reading.

The book will undoubtedly help the specialist to see his field in better perspective and to comprehend the significance of work in allied spheres. It also calls attention to the

enormous, increasing and still largely unsolved problem of effectively communicating the vast amount of specialized information which is made available as a result of the great speed and scope of research throughout the world today.

HEALTH PHYSICS INSTRUMENTATION—Vol. 1

J. S. HANDLOSER

LONDON: PERGAMON PRESS. 1959. 182 PP. £2 2S.

THIS book gives descriptions, characteristics and uses of the common types of radiation detector used by health physicists. The subject-matter covers radiation detectors, portable survey instruments, fixed monitors, neutron monitors, counting-room equipment, calibration techniques and contamination monitors. There is also an introduction to radiation units and limits of radiation exposure.

The treatment is systematic and clear and reflects the considerable experience of the author. The work can be recommended as a concise introduction to its subject.

STOSSERSCHEINUNGEN IN ELEKTRISCHEN MASCHINEN

B. HELLER and A. VEVERAKA

BERLIN: VEB VERLAG TECHNIK. 1957. 464 PP. DM40

IN the 45 years which have elapsed since the first classical investigations of the penetration of surges into transformer windings, several hundred papers have been published on this unusually complex subject. The Czech authors of this book belong to the small group of workers who, by their physical insight and mathematical ability, have succeeded in advancing the problem to a notable degree.

The text not only covers transients in transformers but also deals with surge generators, voltage dividers, surge testing of transformers, detection of winding faults, and transients in rotating machines. For the expert its outstanding value lies in previously unpublished information on the free oscillations of capacitively and inductively coupled windings and on transients in regulating and auto transformers.

The mathematical treatment throughout uses the differential calculus with the Laplace transform. However, for the non-mathematical reader, conclusions are clearly given and a large number of test results and practical examples are included. The volume has no equivalent in the English language and can be described confidently as a unique comprehensive treatise on transients in windings.

ELECTRONIC COMPONENTS HANDBOOK—Vol. 3

K. HENNEY, H. MILEAF and C. WALSH (*Editors*)

McGRAW-HILL. 1959. 180 PP. £3 17S. 6D.

THIS third part of a handbook on American military-type electronic components, sponsored by the Wright Air Development Center of the U.S. Air Force, deals with transformers and inductors, connectors, wire and cable, terminals, valve shields and hardware. It would have been helpful to have included in it a cross-reference to the contents of the previous volumes.

The text is an assemblage of assorted facts on American component practice and MIL-specifications, and is presented in a rather piecemeal manner. While much of the information is of general interest, such as the description of different types of transformer and the limitations on design imposed by environmental conditions, there are textbooks written in this country which deal with such matters more adequately.

The book is likely to appeal mainly to those interested in American military practice, and to those studying the export market. In view of the tendency for NATO military specifications to be drafted largely on the basis of American usage, the bias of the treatment is not so detrimental as might be thought at first sight.

ULTRASCHALL

L. HERFORTH and H. M. WINTER

LEIPZIG: B. G. TEUBNER VERLAG. 1958. 235 PP. DM12

THIS is an introduction to a wide subject, suitable for engineers or physicists wishing to learn more about the application of ultrasonics to industry, biology and medicine.

After devoting the first 30 pages to descriptions of the various forms of ultrasonic generator, the authors consider the physical properties of ultrasonic waves and methods of detecting and measuring them. Pp. 67–137 deal with industrial applications, including non-destructive testing, flaw detection, echo-sounding, emulsification, laundering, gas purification, etc. Non-destructive testing is largely confined to measurements on metals. In all these sections the relevant formulae are quoted but not deduced.

Reference is made to the biological effects of ultrasound on insects, microbes, bacteria and viruses. As regards medicine, the size of the dose to be used in therapy is discussed and accounts are given of techniques, such as that employing pulses, for overcoming some of the difficulties. The use of ultrasound in diagnosis is explained, particularly its employment to locate tumours and cancer.

The work contains 562 references, many of German origin. The electronic equipment mentioned is usually of German manufacture. Many of the chapters are brief and with few details but the book forms a useful guide to wider reading on any of the topics examined.

NATURE AND PROPERTIES OF ENGINEERING MATERIALS

Z. D. JASTRZEBSKI

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 1959. 571 PP. £4 8S.

I AM not very familiar with the teaching of engineering students, but by long association I have found that practising engineers are relatively unaware of the complexity of the materials they use and consequently they are reluctant to call for expert advice when necessary. In principle, therefore, the attempt of the author to enclose in a single volume the basic theories applicable to materials is wholly welcome. In practice, however, it seems to me to demonstrate that it is an impossible task.

It may be positively dangerous to give an impression that

a student who is acquainted with the contents of the book has a reasonable knowledge of the elements of the subject. Four pages are given to fatigue of metals and ten to creep, two most important engineering properties, but four pages are wasted on the extraction of metals. Many other examples could be quoted of both totally inadequate treatment and of waste of space.

Quite valuable references are listed at the end of each chapter, but the reader who turned to some of the specialized works would find them very difficult if the preceding rather brief text was the only knowledge he had of the topics.

There may be students who would find this publication useful, but it is not one that I would recommend myself.

L. ROTHERHAM

PHYSIK DER HALBLEITER

A. F. JOFFÉ

BERLIN: AKADEMIE-VERLAG. 1958. 400 PP. DM35

PROF. Joffé is known internationally as the doyen of workers on semiconductors in the Soviet Union and is director of the Leningrad Institute for Research in Semiconductors. This reviewer made good use of Joffé's original monograph 'Semi-conducteurs électroniques' published in Paris in 1935 when the subject was in its infancy.

The present volume is a translation from the book originally published in Russia early in 1957. Inevitably, certain recent aspects are omitted, but, as a general text covering the whole topic, it is a very useful addition to the literature. There is rather more emphasis on ionic conduction than in British and American works, the problem of the solid–liquid transition is discussed, and although band theory appears throughout the pages, much of the theory is introduced via an atomistic approach. A brief account of Pekar's theory of polarons is included. One useful chapter is devoted to experimental methods for the determination of semiconductor parameters.

A few minor misprints were noted, but the major disadvantage to the reader wishing to refer to specific items is the absence of an alphabetical index. The literature references are extensive and drawn from several countries.

MATERIALS FOR NUCLEAR REACTORS

B. KOPELMAN (*Editor*)

McGRAW-HILL. 1959. 411 PP. £4 13S.

DURING the last few years there have been large numbers of research and development reports published in connection with the atomic-energy industry. This book surveys the fields of extraction, fabrication and testing of fuel-element and reactor-core materials.

The chapter on extraction is a very comprehensive précis of current and historic practice in the United Kingdom, the United States, France and Belgium in the preparation of uranium, thorium, zirconium and beryllium. Physical and mechanical properties are also dealt with and typical data are quoted, although it is not sufficiently emphasized, for uranium and beryllium, that variations in the levels of impurity cause marked differences in these properties.

Fuel-element fabrication practice in the United States is covered fairly thoroughly and the techniques used are amply illustrated. The theories of irradiation damage and the basic effects of irradiation are summarized but the editor has, very wisely, declined to present vast amounts of data having only very limited application.

The volume will serve as a comprehensive introduction to the topic of nuclear materials, with special emphasis on those in use in the United States.

THE THEORY OF OPTIMUM NOISE IMMUNITY

V. A. KOTEL'NIKOV

McGRAW-HILL. 1959. 140 PP. £2 18S.

THIS is the first English-language account of Dr. Kotel'nikov's 1947 doctoral dissertation at the Molotov Energy Institute. It is both an interesting addition to the current literature on the statistical theory of signal detection and a study of considerable historical interest. Three general classes of signals are considered: discrete signals, e.g. teleprinter codes; 'parameter-valued' signals, such as are used in multiplex telemetry; and continuous waveforms, e.g. speech. The concept of 'noise immunity' is defined in terms of either discrete error probabilities or a mean-square error criterion, depending on the signal class.

The author first sets forth the mathematics which describes the effects of noise on a class of signals, and then establishes the conditions for optimal noise immunity and determines the irreducible degradation when these conditions are satisfied. Nearly all practically important modulation schemes, e.g. a.m., f.m., p.p.m., p.a.m., f.s.k., etc., are used to illustrate the general results. Throughout the text, however, 'noise' is defined as additive distributed noise, and other types of disturbance are not considered.

Many of Kotel'nikov's 1947 results have been developed independently (and sometimes more elegantly) by Woodward, Siegert, Middleton, and others. However, Western literature dealing with 'complicated' statistical decision processes, such as f.m. with continuous waveforms, is meagre, and some of Kotel'nikov's results are undoubtedly new to us.

While the treatment is necessarily mathematical in nature, the level of the mathematics is such that anyone reasonably familiar with Fourier series, probability distributions, and statistical dependence can follow the development. The language is mainly that of the engineer rather than the mathematician. In the reviewer's opinion, the book contains much useful material for anyone who wishes to broaden his understanding of signal detection. Unfortunately, the publishers chose to produce it by a photo-offset process, and the hand-written symbolism in some of the equations leaves much to be desired.

LINEAR CIRCUIT ANALYSIS

B. J. LEY, S. C. LUTZ and C. F. REHBERG

McGRAW-HILL. 1959. 567 PP. £4 17S.

THIS textbook on the theory of lumped-constant electrical networks is written at the level of the final year of a degree course. The first two sections examine methods of formulating the equations defining the behaviour of electric circuits, and

the following chapter deals with the solution of these equations for steady-state sinusoidal input signals.

Chapter 4 treats the classical, operator D, methods of solving the integro-differential equations, and after two sections on the Fourier series and integral there is a chapter on the use of the Laplace transformation. In the final section the authors discuss various network theorems and equivalences. An excellent and extensive chapter on mechanical analogues is fitted into the middle.

The book is concerned with networks in general and does not show any marked bias towards any particular branch of electrical engineering. Any teacher or other prospective reader who approves of the order and content of the section headings is unlikely to find a book dealing with these problems, at this level, in a clearer manner. Material descriptive of practical engineering problems is integrated with an exceptionally lucid mathematical treatment, so that even those who prefer an alternative approach to network theory may gain from a study of the work.

PROCEEDINGS OF AN INTERNATIONAL SYMPOSIUM ON THE THEORY OF SWITCHING
Parts 1 and 2 (2 Vols.)

CAMBRIDGE, MASS: HARVARD UNIVERSITY PRESS. LONDON: OXFORD UNIVERSITY PRESS. 1959. 650 PP. £6

THESE two volumes contain 39 papers delivered at Harvard in April 1957. A majority (28) are from American sources; there are 3 from Russia, 8 from seven European countries, but none from Britain. Many of the contributors are well known for their work in this field.

The papers fall into four main groups: abstract theory, theory of certain types of contact network, practical instrumentation, and surveys of developments in specific countries; as one might reasonably expect from the title, the first two groups predominate both in length and in substance. Logical and switching functions are treated by most of the available methods: topology (J. P. Roth), tabulation (T. Singer, R. Ashenhurst), sets and lattices (G. Kurepa, R. Ashenhurst), graph theory (R. Gould), matrices (W. Semon), Boolean vector space (S. Seshu), and mechanical aids (A. Svoboda).

Certain types of system are dealt with specifically: multiterminal contact networks (G. N. Povarov, P. Calingaert, V. N. Roginskij), sequential operations (M. Rubinoff, D. Huffman), systems with storage (A. van Wijngaarden), asynchronous systems (D. E. Muller), and growing or infinite systems (A. W. Burks). Two interesting, and unusual, subjects are multipurpose logical devices (B. Dunham) and the analogy between contact and linear networks (V. Belevitch). Most of these papers are accessible only to readers familiar with symbolic logic and Boolean algebra.

In contrast, there is a delightfully simple algorism for the shortest path through a maze (E. F. Moore), an outline of telephone switching networks (B. D. Holbrook) and an elegant piece of classical analysis applied to discrete functions (probably the last paper on one of his favourite topics by the late Prof. van der Pol).

The practical devices considered are semiconductor and magnetic elements, chemical switches, cryotrons and microwave components. The magnetic topics include a good general survey (J. Rajchman), shift registers (Way Dong Woo), selector switches (M. Karnaugh), ferroresonance (J. G. Santesmases), and a simultaneous-access matrix (R. C. Minnick). The semiconductor aspects include transistor-diode logic (W. B. Cagle) and direct-coupled transistor logic (R. Kudlich); the latter paper is notable for giving some attention to the interaction between circuit and logical design. There is one paper each on cryotron stores (A. E. Slade), microwave logic (W. D. Lewis) and chemical switches (B. K. Green *et al.*).

The national surveys are of Spain (J. G. Santesmases), Germany (A. Walther), and Russia (M. A. Gavrilov). The last is the longest and most comprehensive: of especial interest are the remarks on the automatization of relay network analysis and synthesis.

As usual in a compilation of this kind, the standard is uneven; but most of the papers are valuable either as original work or as surveys, and some of the theoretical ones will probably remain useful references for many years to come. Few individuals are likely to wade through the whole, but organizations working in this sphere should have both volumes in their libraries.

PRINCIPLES OF ELECTRICITY AND MAGNETISM
Y. ROCARD

PITMAN. 1959. 779 PP. £3 10S.

THIS work has 48 chapters in its nine parts, which are: electrostatics, magnetism, electrokinetics, electrodynamics, alternating currents, propagation and radiation, free electron, electrolysis, units. It was developed out of a course of lectures delivered by the author, Professor of the École Normale Supérieure in the University of Paris, at the Sorbonne in 1941–42, an occupation that no doubt took his mind off the Occupation.

Lecture notes however are not suitable for direct publication unless their theme is exceptionally clear and coherent. The treatment does not achieve coherence. The problem of units, for example, is referred to in many places in a way that suggests a passage of years. E.S.U. and e.m.u. are used both separately and together; and sometimes B and H mean the same thing and sometimes they do not, occasionally in consecutive paragraphs. Part 9 on units observes that the M.K.S. system will doubtless, within the near future, displace the traditional C.G.S.

The book's aim is to present to students of physics a modern approach and an extensive consideration of technical applications. The earlier parts are not modern in the electrical engineer's understanding of the term, and although copious notes are given (e.g. on the proximity fuse) the references to application are often naïve. Thus large industrial transformers are credited with efficiencies between 90 and 95%; their immersion in oil is to prevent hum if the voltages are too high—a matter more important than cooling, which can be improved by blackening the coil surfaces. Part 1 starts off with the ebonite–catskin–pithball routine, with no reference to any other means for producing electrification. Part 2 is based on the isolated magnetic pole.

The text, very competently translated by G. F. Herrenden Harker, is more descriptive than analytic. It will raise smiles to the lips of the electrical engineer: but perhaps these would only be the obverse of the physicist's who reads the efforts of the electrical engineer straying into physics. And it is only fair to stress that the author has the student physicist in mind.

MODERN NETWORK ANALYSIS

F. M. REZA and S. SEELY

McGRAW-HILL. 1959. 373 PP. £3 17S. 6D.

THESE authors, while aiming to provide a broad understanding of modern network analysis, give at the same time a quite useful survey of mathematical techniques of value in network theory.

An introductory chapter concerned with linear systems is followed by work on elementary functions of a complex variable, dealing, in particular, with pole-zero configurations corresponding to various network transfer functions. The properties of determinants and matrices required later in the text are developed, and elementary ideas of topology are introduced to be related to linear graphs derived from networks, which then lead to the formation of matrices giving branch currents and potentials.

Later sections are concerned with network equilibrium equations, filters, transmission lines, and with linear networks in the transient state. Among important topics treated are the natural modes and the stability of linear systems, the response of linear systems to unit-step and to unit-impulse functions, and the general properties of network functions. There is also a chapter on the Laplace transform and its basic properties, with application to the solution of differential equations. However, space should also have been found for an introduction to the Fourier transform, in view of its application to the response of linear systems.

The book can be recommended to the qualified engineer or advanced student interested in network analysis, but it would have been of greater value to the latter if all solutions to the problems set had been given.

ENCYCLOPEDIC DICTIONARY OF ELECTRONICS AND NUCLEAR ENGINEERING

R. I. SARBACHER

PITMAN. 1960. 1417 PP. £8

THE reviewer shrinks before the magnitude of this volume. The first impression is of its sheer physical size, for, according to the publishers, Dr. Sarbacher has written over 14000 entries comprising a total of more than a million words—an undertaking that occupied him for 12 years. In addition to this, the work is one of considerable scholarship. Every entry one reads is well written and concise, but does not sacrifice intelligibility for brevity. Neat diagrams and numerous tables are provided wherever the definition requires them.

If any criticism is to be made at all, it is that the author, in combining electronics with nuclear engineering, has perhaps attempted to cover too wide a field. The subjects are essentially disparate, and the net effect of this dual approach is to make the dictionary rather diffuse. However, there is no doubt that electrical engineers engaged in nuclear technology will find the combination useful. Nuclear physicists, too, have here a valuable source of information.

Although most will be of lasting value, there are parts which will inevitably become obsolete—the list of nuclear reactors for example. It is to be hoped that Dr. Sarbacher will keep future editions of his excellent book abreast of progress—a Sisyphean task to add to his Herculean labours.

SOLID STATE PHYSICS—Vol. 7

F. SEITZ and D. TURNBULL (*Editors*)

NEW YORK: ACADEMIC PRESS. 1958. 525 PP. $14

THIS volume conforms closely to the general pattern of its predecessors in presenting a series of up-to-date reviews of different branches of solid-state physics written by acknowledged experts. One exception to this is the paper by H. W. Lewis on wavepackets and the transport of electrons in metals, which is an original contribution to the theory of scattering.

P. G. Klemens considers thermal conductivity and lattice vibrational modes, a topic of considerable importance in connection with thermoelectric power generation. His paper is followed by two reviews of available data on a wide variety of materials. J. Callaway is concerned with the calculations of electron energy bands, while H. B. Huntington collects the elastic constants of crystals and discusses the methods employed to determine them.

The use of new tools such as the ion gauge, the field-emission and the field-ion microscope in the study of surfaces is dealt with by J. A. Becker. The final contribution, on the structure of crystals, is by A. F. Wells. He approaches the subject from the viewpoint of topology, rather than from the conventional one of lattices and symmetry.

THE ELECTRIC ARC

J. M. SOMERVILLE

METHUEN. 1959. 150 PP. 12S. 6D.

PROF. Somerville is to be congratulated on this addition to the Methuen Monographs on Physical Subjects. In some 35000 words and 40 Figures he contrives to give a clear and up-to-date account of the electric arc which although written primarily for students and other newcomers to the field will, with its 186 references, be useful to those working on gas discharges.

After a brief introduction, in which the basic characteristics of arcs are considered, the most recent data are used in a description of the positive column of the high-pressure arc. Spectrographic and other methods of arc-temperature measurement, for up to 6×10^4 °K, are mentioned, and the effect of generalized thermal conductivity on temperature profiles is discussed. The equality of gas and electron temperatures in the high-pressure positive column is demonstrated by a simple worked example. The applications of arcs as light sources and the possible thermal release of nuclear energy are touched on.

The next major section deals with electrode processes. The most modern theories are described, not neglecting retrograde

motion of cathode spots which the author calls 'one of the minor mysteries of physics'. It is a rather sobering thought that even now the mechanism of the cold-cathode spot is not completely explained. There is a short chapter on the spark, and on other methods of initiating arcs.

One statement in the introduction must be questioned. The author says that 'the most characteristic feature of an arc is the low value of the cathode fall'. Surely a low gradient in the positive column is the main distinguishing feature? Atmospheric-pressure arcs in hydrogen with a constricted column and passing currents of 10amp or more can exist with a glow-type cathode mechanism having a cathode fall of 300 volts.

The book can be recommended as a very readable introduction to the electric arc.

ELECTRICAL CIRCUIT ANALYSIS

K. STEPHEN

CLEAVER-HUME. 1960. 259 PP. 30S.

THE degree and diploma student, for whom this work is intended, would find nothing in it that was not already treated in the handful of textbooks covering his basic studies in electrical power and electronics. It provides some elaboration here and there, an occasionally more detailed explanation than the general textbook, and many numerical examples, but not the kind of unifying treatment to justify a separate book.

Circuit analysis proper is limited to d.c., single-phase a.c. and polyphase systems, with not even a hint about the general methods of specifying and analysing quadripoles. Field problems like electromagnets and graded capacitors find an uncomfortable place in the text in the guise of magnetic and dielectric circuits. An advanced student or practising engineer would find much of the volume tedious: a beginner might justifiably find some of it—especially the a.c. analysis—rather mystifying.

DIGITAL AND SAMPLED-DATA CONTROL SYSTEMS

J. T. TOU

McGRAW-HILL. 1959. 631 PP. £5 16S. 6D.

THIS is the third volume devoted entirely to sampled-data control systems which has appeared in the English language. Like its predecessors by Ragazzini and Franklin (reviewed in the May 1959 *Journal*, p. 326) and by Jury (reviewed in the June 1959 *Journal*, p. 393) it is American, and consequently a considerable similarity in methods is apparent.

Prof. Tou's work is more than just a new version of previous texts, however, for it contains a considerable amount of material not covered in the earlier publications. In addition to such standard sections as those on sampling, Z-transform analysis and pulsed-network and continuous-compensation methods, there are chapters on an analysis of quantization, analogue–digital conversion and systems with finite pulse width.

A section on optimum control includes a short and purely theoretical application of the Wiener optimum-filter theory to sampled-data systems and an almost negligible account of adaptive control systems. Most readers will be already well versed in continuous-control-system theory. Chapter 2, which sets out to review this, could therefore have been omitted.

For the postgraduate student or the practising control engineer who wishes to learn about sampled-data systems the treatment can be highly recommended. The many worked examples, the 238-item bibliography, a large number of interesting problems (without answers) and a generally clear and thorough presentation of the material make this a useful book.

MASERS

G. TROUP

METHUEN. 1959. 168 PP. 13S. 6D.

THIS latest addition to the publisher's series of Monographs on Physical Subjects is to be welcomed since it gives an up-to-date account of a subject of great topical interest.

After a very brief introduction, the author discusses the quantum-mechanical theory of spontaneous and stimulated emission of radiation from excited atomic and molecular systems. This leads to a consideration of the possibility of obtaining amplification from such systems, of methods which may be used to excite them, and of the general theory of amplifiers and oscillators based on stimulated emission. These topics occupy about two-thirds of the volume. The remaining third is largely devoted to an account of experimental work on the subject.

The book is perhaps better suited to the needs of the physicist than to those of the electrical engineer, unless the latter has a good grasp of the elements of quantum theory. It can be read with greatest profit by those who are already familiar with the general principles of maser action.

SERVOMECHANISM FUNDAMENTALS

B. ZEINES

McGRAW-HILL. 1959. 257 PP. £2 3S.

THIS is an extremely elementary treatment which will be of interest to those requiring a guide to the operation of simple servomechanisms. It does not deal with the theory of feedback control systems and hence its title is misleading. The standard may be assessed by the fact that, a quarter of the way through the work, the author sees fit to describe a sinusoidal wave.

No mathematics is employed in the text; the analysis of a position-control system is given in an appendix using a second-order linear differential equation. Transient solutions are obtained by classical methods. The transient performance of a d.c. motor in operational notation is also developed in an appendix.

In a volume at this level there are bound to be overgeneralizations, such as the description of derivative control which 'provides damping by making an increasing error appear larger and a decreasing error appear smaller'. Nevertheless it is an excellent book for those for whom it is intended. It is aimed at the technician or maintenance mechanic who wants to know what are the functions of the various components of a control system.

*Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members

LIBRARY ACCESSIONS

BOOKS

ALEXANDER, J. 37

Scientific manpower

London: Hilger and Watts, 1959. pp. viii, 135. 19 × 12·5cm. 15s.

A study of the shortage of scientific manpower and its relation to the teaching of science and technology. Technical education in other countries, scientific womanpower, graduates in industry and higher technological education are some of the aspects of the subject considered. Reviewed in February 1960 *Journal*, p. 117.

BEAN, R. L., and others 621.314.2

Transformers for the electric power industry*

New York and London: McGraw-Hill, 1959. pp. vii, 409. 23·5 × 15·5cm. £4 17s.

This is intended not for the transformer specialist but for power engineers who need to know something of the fundamental theory, design, construction, use and maintenance of transformers. Bibliographical references to more advanced literature follow the chapters. This book is reviewed on p. 240.

BERSHADER, D. (*Editor*) 538.31

The magnetodynamics of conducting fluids

Stanford: Stanford University Press, 1959. pp. viii, 145. 23·5 × 16cm. $4.50

Seven analytical papers from the proceedings of the third annual symposium on the subject in which the emphasis is on conducting fluids in magnetic fields.

BROWN, H. G. 621.355

The lead storage battery. 4th edition

Altrincham: John Sherratt, 1959. pp. 166. 22·5 × 14·5cm. 24s.

A simple description of the chemistry of the lead–acid cell, its construction and electrical characteristics, and battery maintenance and testing. Deals mainly with stationary batteries, but traction and special-duty batteries are briefly described.

CARTER, C. F., and WILLIAMS, B. R. 001.8

Science in industry; policy for progress

London: Oxford University Press, 1959. pp. ix, 186. 22 × 14cm. 21s.

The third of a series of reports written for the Science and Industry Committee set up by the Royal Society of Arts, the British Association and the Nuffield Foundation. The first two reports surveyed the factors which affect the rate of application of new scientific ideas. This report contains suggestions for policy and actions by industry and Government which may assist in the fruitful application of science. This book is reviewed on p. 240.

ELENBAAS, W. (*Editor*) 621.327

Fluorescent lamps and lighting*

London: Cleaver-Hume, 1959. pp. x, 346. 23 × 15cm. £2 15s.

Explains from first principles the construction and mode of operation of fluorescent lamps. Up-to-date information is given on how they can be used to the best advantage, and is illustrated by descriptions of outstanding examples of modern lighting practice.

GIBSON, A. F., and others (*Editors*) 621.315.59

Progress in semiconductors—Vol. 4*

London: Heywood, 1960. pp. vii, 291. 25·5 × 16cm. £3 3s.

This latest annual volume in the series contains contributions on liquid semiconductors, the oxidation of germanium surfaces, high electric field effect, and the dielectric properties of solids in relation to imperfections. This book is reviewed on p. 241.

HELLER, B., and VEVERAKA, A. 538.551

Stosserscheinungen in elektrischen Maschinen (Surge phenomena in electrical equipment)

Berlin: VEB Verlag Technik, 1957. pp. 464. 21 × 15cm. n.p.

Discusses the co-ordination of insulation levels, surge phenomena in coils, transformers and rotating machines, surge generators and the measurement of surges. This book is reviewed on p. 242.

HERSEE, E. H. W. 518.5

A simple approach to electronic computers*

London: Blackie, 1959. pp. viii, 104. 19 × 12·5cm. 12s. 6d.

Presents the basic working principles of digital and analogue machines. Reviewed in February 1960 *Journal*, p. 119.

HODGMAN, C. D. (*Editor*) 53(083)

Handbook of chemistry and physics; a ready-reference book of chemical and physical data. 41st edition

Cleveland: Chemical Rubber Publishing Co., 1959. pp. xxiv, 3471. 18·5 × 12cm. £5 5s.

IMHOF, A. 621.315.6

Elektrische Isolierstoffe (Electrical insulators). **2nd edition**

Zürich: Orell Füssli Verlag, 1949. pp. 272. 23 × 16cm. £2

A general work on the mechanical, physical and electrical properties of various types of insulating material.

LOOCKE, G. 621.313.236

Elektrische Maschinenverstärker (Rotating amplifiers)

Berlin: Springer-Verlag, 1958. pp. viii, 294. 24 × 16cm. £3 11s. 9d.

Discusses the use of rotating amplifiers in control circuits, their design characteristics and performance. Applications in Ward Leonard systems for mining, foundry and rolling-mill machinery are described.

MARKUS, J. 621.385

Handbook of electronic control circuits*

New York and London: McGraw-Hill, 1959. pp. xii, 347. 28·5 × 22cm. £3 6s.

A collection of over 250 significant industrial electronic circuits published in *Electronics* in the period 1956–1959. Each circuit is described, and values of components are given. The volume is a sequel to 'Handbook of industrial electronic control circuits' and 'Handbook of industrial electronic circuits'. Reviewed in February 1960 *Journal*, p. 120.

NALDER, R. F. H. 93.621.39

The Royal Corps of Signals; a history of its antecedents and development (*circa* 1800–1955)

London: Royal Signals Institution, 1958. pp. xvi, 672. 24·5 × 15·5cm. 30s.

NEETSON, P. A. 621.314.7

Junction transistors in pulse circuits*

London: Cleaver-Hume, 1959. pp. viii, 139. 24 × 15cm. 27s.

Gives an explanation of the fundamental principles of pulse-circuit design and the analytical treatment of circuits containing transistors.

Library accessions (continued)

PAGE, C. H. 621.38(076)

The algebra of electronics*

New York and London: Van Nostrand, 1959. pp. x, 258. 24 × 15·5cm. £3 6s.

A knowledge of simple differential calculus is sufficient to follow the development of networks, from the simple d.c. circuit to a.c. circuits involving transformers and thermionic devices, and the treatment of noise, distortion and modulation. The book contains many worked examples and problems for the reader to solve. Reviewed in October 1959 *Journal*, p. 605.

PEEL, H. I. F. 621.396

Elements of radio engineering. 2nd edition*

London: Cleaver-Hume Press, 1960. pp. vii, 257. 19·5 × 13cm. 13s. 6d.

An elementary book which assumes only a limited knowledge of electricity and magnetism and no knowledge of a.c. theory.

PORGES, J. 697

Handbook of heating, ventilating and air conditioning. 4th edition*

London: George Newnes, 1960. pp. vii, 227. 22 × 14·5cm. 30s.

Contains data, charts and tables required for day-to-day reference, and also a comprehensive bibliography relating to the theoretical aspects of heating and ventilating.

ROCARD, Y. 537

Principles of electricity and magnetism*

London: Pitman, 1959. pp. x, 779. 22 × 14cm. £3 10s.

Suitable for students reading for a degree in physics; the modern approach to the subject is illustrated by the space devoted to electronics. This book is reviewed on p. 244.

SMITH, R. A. 621.315.59

Semiconductors*

Cambridge: University Press, 1959. pp. xvii, 494. 24 × 15·5cm. £3 5s.

Gives a comprehensive account of the physics of semiconductors and a review of their applications. It includes discussion of impurities, thermal, optical and high-frequency effects, and methods of determining characteristic properties. Reviewed in January 1960 *Journal*, p. 46.

SOMERVILLE, J. M. 537.523

The electric arc

New York: John Wiley. London: Methuen, 1959. pp. ix, 150. 17 × 11cm. 12s. 6d.

This Methuen Monograph is an explanation of the physical nature of arc behaviour. It is reviewed on p. 245.

STEPHEN, K. 538.551

Electrical circuit analysis*

London: Cleaver-Hume, 1960. pp. 259. 22 × 14cm. 30s.

Aimed at students taking a general degree in electrical engineering. Contains worked examples and problems (with answers) for the student to solve. This book is reviewed on p. 246.

THOMAS, A. G., and RATA, P. J. H. 621.316.53

Aluminium busbar

London: Hutchinson, 1960. pp. 105. 24·5 × 15·5cm. 21s.

Aluminium is being increasingly used as a busbar material. It is cheaper than copper; an aluminium busbar weighs half as much as a copper busbar of equivalent current-carrying capacity. This handbook gives data on the design, construction and installation of aluminium and aluminium-alloy busbars.

VEINOTT, C. G. 621.313.3

Theory and design of small induction motors*

New York and London: McGraw-Hill, 1959. pp. xv, 477. 24·5 × 15·5cm. £5 4s. 6d.

Gives a non-mathematical descriptive account of the principles of the induction motor. Theory, performance-calculation methods and evaluation of basic constants are treated. Design procedures are explained. This book will be reviewed in a future issue.

VENIKOV, V. A., and IVANOV-SMOLENSKY, A. V. 621.3.001.8

Physicheskoe modellirovanye electricheskikh system (Simulation of power systems)

Moscow: Gosudarstvennoe Energeticheskoe Izdatelstvo, 1956. pp. 359. 22·5 × 15cm. n.p.

WARFIELD, J. N. 518.5

Introduction to electronic analog computers

London: Prentice-Hall, 1959. pp. ix, 175. 24·5 × 15·5cm. 30s.

Considers the use of analogue computers for dealing with engineering problems. Reviewed in November 1959 *Journal*, p. 664.

WILSON, H. A. 537.1

Modern physics. 4th edition*

London: Blackie, 1959. pp. xv, 473. 22·5 × 15cm. £2

A concise treatment for students taking an honours course in physics. This edition contains new chapters on semiconductors, low-temperature physics and elementary particles.

OTHER PUBLICATIONS

ADVISORY COUNCIL ON SCIENTIFIC POLICY
COMMITTEE ON SCIENTIFIC MANPOWER

Scientific and engineering manpower in Great Britain 1959

London: Her Majesty's Stationery Office, 1959. pp. vi, 48. 24·5 × 15·5cm. 3s.

BRITISH BROADCASTING CORPORATION

The equipment of the B.B.C. television film studios at Ealing, by N. F. Chapman. Engineering Monograph No. 27

London: B.B.C., 1960. pp. 31. 28 × 22cm. 5s.

HARVARD UNIVERSITY, COMPUTATION LABORATORY

Proceedings of an international symposium on the theory of switching. 2nd–5th April 1957. Parts 1 and 2

Cambridge, Mass.: Harvard University Press, 1959. pp. xl, 305; 345. 27·5 × 20cm. £6

Reviewed on p. 244.

INTERNATIONAL ASTRONOMICAL UNION

Paris symposium on radio astronomy. I.A.U. symposium No. 9 and U.R.S.I. symposium No. 1, held from 30th July to 6th August 1958. Edited by R. N. Bracewell

Stanford: Stanford University Press, 1959. pp. xii, 612. 24 × 16cm. £6

INTERNATIONAL ATOMIC ENERGY AGENCY

Nuclear electronics. Proceedings of the international symposium on nuclear electronics organized by the French Society of Radio-electricians, Paris 1958. Two volumes

Vienna: International Atomic Energy Agency, 1959. pp. xii, 830. 24 × 16cm. £2 8s.

INTERNATIONAL RADIO CONSULTATIVE COMMITTEE (C.C.I.R.)

Documents of the IXth plenary assembly, Los Angeles, 1959. Three volumes

Geneva: International Telecommunications Union, 1959. pp. 336; 207; 423. 25 × 17·5cm. £5

ORGANISATION FOR EUROPEAN ECONOMIC CO-OPERATION

Towards a new energy pattern in Europe. Report of the Energy Advisory Committee

Paris: Organisation for European Economic Co-operation, 1960. pp. 125. 24 × 15·5cm. 9s.

OXFORD UNIVERSITY DELEGACY FOR EXTRA-MURAL STUDIES

Abbreviated proceedings of the Oxford mathematical conference for schoolteachers and industrialists at Trinity College, Oxford, 8th–18th April, 1957

London: Times Publishing, 1957. pp. 111. 25 × 15·5cm. 2s. 6d.

UNIVERSITY OF CALIFORNIA

Statistical methods in radio wave propagation. Proceedings of a symposium held at the University of California, Los Angeles, 18th–20th June 1958. Edited by W. C. Hoffman

London: Pergamon Press, 1960. pp. xiii, 334. 25·5 × 17cm. £4 10s.

THE INSTITUTION EXAMINATION

List of successful candidates

THE INSTITUTION EXAMINATION (PART I) OCTOBER 1959

BRITISH ISLES AND OVERSEA

The following have satisfied the examiners in the compulsory subjects of Part I (mathematics; applied mechanics; heat, light and sound; principles of electricity; and engineering drawing):

BONNERJEE, Nityananda
DAVIES, David James Frederick
JAYATUNGE, Nihal Gamini Perera
LEWIS, James Beverley
O'RIORDAN, Noel James
WEAVER, Leonard John
WEBB, David Albert

The following candidates have satisfied the examiners in the subject of English:

ARNEBERG, Per Aanund
DAVIES, James Frank Clifford
FREEMAN, Loyal Archibald
HALEY, Willie
HAY, Thomas Turnbull
HINKLEY, Albert Arthur
MALLALIEU, Bryan
MAVROMIHALES, Andreas John
SENIOR, William Arthur
THADANI, Kishin Lakhi
WADVA, Kuldip Singh
WHITEHEAD, Norman Walter
WOOD, Harold Simpson

The following candidates have been permitted to enter the Examination under special conditions and have satisfied the examiners in heat, light and sound:

JENKINS, David Ieuan Thomas
PACKER, Timothy John
SHEPPARD, John
WHITEHEAD, Norman Walter

THE INSTITUTION EXAMINATION (PART II) OCTOBER 1959

BRITISH ISLES

ARMSTRONG, Malcolm Sneddon[4]
BALDWIN, David Arthur[2]
BARKER, Maurice[3 4]
BECKENHAM, Brian Francis[1]
BOARDMAN, Richard Malcolm[1]
BRYSON-HAYNES, Donald (passed April 1959)[2]
BYE, Keith Leslie[4]
CHAPMAN, Terence Raymond[2]
CLEWS, Dudley Ernest[1]
COLDWELL, John Keith[2]
CONNELLY, Ralph[3]
COOPER, Stephen Hilary[3]
DOSHI, Jayantilal Sakalchand[1 4]
DUFF, Jeremy Tindal[3]
DUTTA GUPTA, Ranjit Ranjan
EASLICK, John William[2]
EVANS, Kenneth Stuart[1]
FARRELL, John Joseph
FIFER, Alan George[1]
GARDNER, Stanley John[4]
GIBBON, Robert Roger[1]
GILDER, John[1]
GODIER, Roy Frederick[1]
GOSLING, David Samuel[1]
GRACIE, Richard Arthur
GRIFFIN, Brian[1]
HADEN, Donald Sydney[2]
HAINES, Gordon Edward[1]
HALL, Brian [3 4]
HAWKINS, Arthur Terence[1]
HOGAN, Daniel Joseph
HOWICK, Ronald Edward[2]
HUTCHERSON, Peter[1]
HYDE, David Robert Youngman[1]
IBALL, John Elwyn[4]
JAMIESON, George Frederick Stewart[1]
LAWRENCE, Peter John[2]
LEA, Bernard James[2]
LEE, David Alan[1]
LINES, David[1]
MARTIN, Raymond Geoffrey[2]
MASON, James Douglas[2]
METCALF, John Hugh[3]
MOBBS, John Charles William[2]
NOBES, Michael James[1]
OSBORNE, John Arthur Alan[3]
PARAMESVARAN, Thamotharampillai Vaithilingam[1]
PICKUP, John Frederick[2]
ROLFE, Derek Sidney[2]
ROWE, Barry[1]
SAMARAKKODY, Upali
SCRUTTON, William Henry Charles[3]
SINGHA, Bindhyeshwari Prasad
SMITH, Brian Charles[2]
SPARKES, Peter Robert[2]
STARLING, Donald Sidney[2]
UPTON, Roger Sidney[2]
WHITING, John Percy[2]
WILLIAMSON, Sydney Ernest[1]

OVERSEA

ASHBY, Gerald Terence[3]
BEAUMONT, Raymond Kenneth
BRASSINGTON, William John
CAMPBELL, Kenneth Scott[1 2]
CARDNO, Ian Murray
GOVENLOCK, Terence Edmund[5]
GRICE, Geoffrey George[1 2]
HANLON, Brian Leslie
LEMMON, Anthony William
LEYLAND, Bryan William
SMITH, Ivan Ronald
SOMERS, Desmond James

[1] *Electrical engineering I and II* [2] *Engineering physics* [3] *Thermodynamics* [4] *Mathematics* [5] *Electrical engineering I*

The Institution Examination: List of successful candidates (continued)

THE INSTITUTION EXAMINATION (PART III) DECEMBER 1959

BRITISH ISLES

ABROOK, George Edward[1]
ACHARYYA, Susil Chandra
ANSDELL, Arthur Anthony[1]
ARMITAGE, John Turner
ATKINS, Thomas Edward[1]
ATKINSON, Peter
BAKER, George Edward March[5]
BALDWIN, David Arthur[1]
BALDWIN, Richard Timothy[2]
BARLOW, Michael Neil[6]
BEANEY, Michael Edward[1]
BEESON, Douglas Paul[1]
BEST, Cyril Frank[1 3]
BOWSKILL, David John[1]
BOYCE, Kenneth Ronald[6]
BULL, Donald Malcolm[1]
CASSERLEY, David John[1]
CHAMBERS, Jack[1]
CHEESEMAN, David Edwin[4]
CHILVER, Brian[1]
COLEMAN, Kenneth John[1]
COOKE, Anthony James[1 5]
COOPER, John Brian[1 5]
COWLEY, Alan[1]
CRUICKSHANK, James McNicol[5 7]
CURTIS, Brian William[1]
DEAKIN, Barry[6]
DE WILTON, Michael Sydney[5]
DUNNE, Thomas Francis[1]
DYKES, John Leo[1]
DYMOTT, Peter Harry[3]
EAST, George Frederick[1]
ECONOMIDES, Dionysios Gregoriou[1]
FAWCETT, Brian Jack
FERGUSON, Tony[1]
FERRETT, Neil Antony[3]
FITZPATRICK, Christopher Martin[1]
FOGARTY, George William Alexander[1]
FORD, George[1]
FOSTER, Harold
GEORGE, Emyr[1]
GEORGE, Royston Arthur[1]
GILLANDERS, Robert[3]
GLEESON, Peter Thomas[1]
GOPINATH, Anand[2]
GOTH, Diana Raby[1]
GREGORY, Peter
GROVES, Lyndon Rees[1]
HABENS, Bernard[3]
HANDFORD, Michael Phillip[1]
HARRISON, Raymond Peter Cowper[1]
HICKLING, Brian George[1 2]
HILL, Bryan James[1 4]
HOCKENHULL, Nicholas Charles Headington[1 3]
HODGKINSON, Raymond Thomas[1]
HOLLIS, Frank Charles[1]
HOOPER, Richard Burnett[1]
HORROCKS, Daniel Edward
IVESON, Albert John[3]
JACKSON, David Arfor[1]
JACKSON, Maurice[1]
JONES, Kenneth Barrie
JORDAN, James Redmon[1]
KARAGEORGIS, Ulysses[1]
KENT, Brian Hamilton[1]
KIRK, David William[1]
LACEY, Edward Ernest[1]
LAMB, Bryan Charles Gilbert[6]
LARRY, Ronald[1]
LAVENDER, Anthony William[1 6]
LEWIS, Robert Tony[1]
LEWIS, Vernon John[7]
LISTER, Robert Malcolm
LLOYD, Denis George[5 7]
MARSH, Leonard Maurice[1]
MARTIN, Raymond Geoffrey[1]
MASTERMAN, John Michael
MASTERS, Kenneth William[1]
MICHAEL, Ethelbert Victor[1]
MILES, Clifford Victor Harry[1]
MOORE, Bryan[7]
MORRIS, George Edwin[3]
MORRIS, John Henry[1]
MORTON, John Wilfred[1 4]
NORRIS, Paul Mitchell
OPONG, Nathan[1 7]
OSWAL, Dongerchand Dalichand
OZORO, Okwuesa[1]
PAYNE, David Malcolm
PIERCE, Reginald Roy[3]
POOLEY, Christopher[1]
PRATT, Phillip John
PULANTHIRAN, Eliathamby[1]
REED, Rodney Charles Ernest[1]
ROACH, Maurice Leslie
ROBINSON, Peter Beresford[1]
ROBSON, Brian[5]
ROLFE, Derek Sidney[1]
ROLFE, Patrick James[1]
SMITH, Brian Charles[1]
SMITH, Philip John Mytton[1 2]
SMYTH, Michael Charles[1]
SPARKS, Gordon Leslie[1]
STARLING, Donald Sidney[1]
SUNTHARALINGAM, Nagalingam[7]
TAYLER, Brian Horace Everard
THEAKSTON, James Michael[1]
THICKPENNY, John[1]
THOMAS, David John[3]
THORNCROFT, Roy Charles[3]
THURBIN, Patrick John[1]
TINSLEY, David[1]
TRACEY, Peter Martin
UBOSI, Bertram Ogugua Chukwudozie[1]
WALDRON, Thomas William[4]
WALSH, Steven Roger[1]
WATT, Alan Vallack
WEARDEN, Charles Henry[1]
WEBBER, John George[1]
WEDLAKE, David[1]
WESTON, Anthony Ashby[1]
WHITELEY, Michael Christopher[1]
WICKS, Stuart Edward[1]
WILLDEY, Geoffrey Michael[3]
WILMAN, Hugh[1]
WINDLE, Raymond Frearson[4]
WRIGHT, William[1]

OVERSEA

BADMAN, Ronald George[5 8]
BAILLIE, Theodore Henry[1]
BAYER, Benjamin[1]
CAHILL, Patrick Joseph[8]
CUNNINGHAM, Brian Gordon
FERN, Derek Osmond[1]
GRANGER, Murray James[6]
HOLLOWAY, David Harold[1]
JAMES, Roy Arthur[1 8]
KELMAN, Keith Douglas Edward[1 4]
LEE, Thomas Joe[5]
McINTOSH, Ranald[1 8]
MEYER, Robert James[5]
ROMIJN, Maarten[5]
SIMPKIN, Laurence Edward
SULLIVAN, James Warwick[1]
TAYLOR, Ronald Gordon[1]
TREUREN, Gustaaf Hendrik George[1]
VELTMAN, Frederik[5]
WU NAN WAH[1 8]
WYKES, Lewis Dellow

[1] *Advanced electrical engineering* [2] *Electrical machines* [3] *Electrical measurements* [4] *Electricity supply* [5] *Electronic engineering* [6] *Utilization of electrical plant* [7] *Radiocommunication* [8] *Line communication*

Elections and transfers

The following elections and transfers approved by the Council are effective from the 1st March 1960

ELECTIONS

Associate Members

CASSIDY, Maxwell, B.SC.
DAVIES, Gordon Lang
GIBB, Lt.-Cmdr. Roy Neil, R.N.
GUEVARA, Emmanuel John, D.F.H.
HOARE, Frederick John
LACEY, Lt.-Col. Desmond Ralph, B.SC.(ENG.), R.E.
OVERBURY, Percival Leonard, B.SC.(ENG.)
OWENS, Henry Charles
SUNDA, Jack Andrew
WELLS, James Owen, B.SC.(ENG.)

Associates

GRIFFITHS, Evelyn Edwin
HAYES, Edwin Hirst
JACKSON, Leslie Irvine
WATT, George

TRANSFERS

Associate Member to Member

ALLWOOD, George Henry
BENNETT, Albert Edward, B.SC.
BURNETT, Raymond Edward, M.A.
CALVERLEY, Thomas Earnshaw, PH.D., B.SC.(ENG.)
CATTLE, William Frederick
DENT, Ivor John Kelvin
GRIFFITHS, Clyde James, M.E.E.
HAMMERTON, Thomas Gordon, B.SC., PH.D.
KEEN, Arthur William
LANGFORD, Cyril Etheridge Rowley, B.SC.(ENG.)
LOMBARD, James Stephen, B.SC.(ENG.)
MALTBY, Robert Williams
MURRAY, John Bernard, B.SC.(ENG.)
SHEPHERD, Norman, M.SC., B.SC.TECH.
TORRANCE, Alexander Edward
WOOLFSON, Mark

Graduate to Associate Member

ASHWORTH, Arthur Frederick Martin, M.ENG.
BANCROFT, Norman Roy
BENNETT, Alfred
CHALK, Colin Leonard, B.SC.(ENG.)
DIXON, William
HAILE, James Neville, B.SC.TECH.
HAINES, Denis Edmund
HALL, David
HANCOX, Roger, B.SC.(ENG.), PH.D.
HARDCASTLE, Frederick William
HARDY, Robert Hugh Desmond
HEDLEY, Harold Norman
HOLT, Alan George James, PH.D.
HOPPER, Hilary
JOB, John Vivian Escott, D.F.H.
KEEP, Arthur Stanley
KIRBY, John Robert, B.SC.
KIRK, Joseph
KIRKWOOD, James Bruce
LARKINSON, Roger Brian, M.A.
LESLIE, Charles McKay, B.SC.
LILLISTONE, Graham Charles
LIPPA, Kurt, B.SC.(ENG.)
LYNCH, Alexander Edward
MACDONALD, William Ronald
MACIEJOWSKI, Andrzej Marian, DIPL.-ING.
MARSDEN, Leonard
MOLE, Norman Frederick, B.SC.
MOORE, Raymond George
MUIR, Robert Alexander
NEWTON, Harold Edward, B.ENG.
NOBBS, Harold
PRATT, Norman George
PRICE, Charles Kenneth John
PRICHARD, Thomas Richard, B.ENG.
PRIOR, James
ROBERTSON, David
SADLER, Allan, M.SC.
SINGH, Bhagwant
STAMFORD-BEWLAY, Philip, B.SC.
SUMMERS, Zdzislaw Ryszard
WALDIE, Robert David, B.E.
WALKER, Frank Edgar
WARWICK, Alan Taylor
WELFORD, James
WESTERHUS, Alfred Ingvar
WHEABLE, Desmond
WHITTINGHAM, James
WHITTLE, Jack, B.A.
WIGHTMAN, George Gillespie
WILLIS Geoffrey William, B.SC.
WREDE, Dennis Frederick
WRIGHT, Albert William

Student to Associate Member

LEONARD, Jack Lawrence, M.SC., PH.D.

The following elections and transfers approved by the Council are effective from the 3rd March 1960

ELECTIONS: 1st LIST

Graduates

BAYER, Benjamin, B.SC.
BENNETT, Frederick John, B.SC.(ENG.)
BOVER, Frank Christopher, B.SC.
DESMOND, Terence Brian
FERGUSON, William Weir, A.R.C.S.T.
GRIMSTON, Derek Frederick
HINE, James Ian, M.E.
HOLLAND, David George, B.SC.(ENG.)
JONES, William Irfon, B.SC.(ENG.)
KOIKE, Ryutaro, B.SC.(ENG.)
McKENDRICK, William John
MAIN, Alexander Donald, B.A.
ROBERTSON, Peter Warner
ROMIJN, Maarten
SABBERTON, Raymond John
SWEET, Brian Herbert
VAN NIEROP, Johann Hugo, B.SC.(ENG.)
YARDLEY, Ralph

Students

AUTON, John Paul
BARRY, William James
BOYLE, Stephen
BRANSON, John, B.SC.
BROCK, Barry Ernest
BROOK, Edward Martin
CATLOW, Martyn Andrew
CHANDLER, Kenneth
COLEMAN, Roger David
COLLINGS, Roger William
COOK, Ronald
COOMBS, David Thomas
CRAWLEY, Brian Frederick
DAVIDSON, Eric George Smart
DAVIDSON, Martin Richard
DEMBLA, Ghansham Tolaram, B.E.
DENNEY, Michael Robert
DUNKLEY, Jeffery John
EDISON, David Michael
EMMETT, David Samuel John
EVANS, Dan
FAVRE, Raymond Albert
FEAR, John, B.SC.
FERNANDO, Thompson Mervyn
FINLAY, William James
FINN, Alan Hugh
FORSYTHE, William
FOWWEATHER, Margaret Mary
FOX, Kenneth John
GLOVER, Brian William
GOODRIDGE, Richard James
GREENWOOD, David
GUPTA, Shankar
GWINNOTT, Roy Vivian
HARRIS, David Morgan
HAYES, Keith
HAYWARD, Robert Alan
HENSON, David Darwell
HERSEY, John Denis
HINTON, James Humphrey
HITCHINGS, Ronald
HODGSON, Brian William
HUMPHRIES, Michael Benedict
HUNT, Peter
JAMES, Christopher Edward
JEFFREYS, David Rhidian
JENKINS, Walter Edward
LEA, Peter
LEE, Melvin
LEVEL, Peter Anthony
LUMB, Christopher
McCOLLAM, Ian Robert Harold
MADNANI, Prakash Lakshmichand
MANDERS, Gerald
MATHEWSON, George Ross
MEIKLE, Hamish Duncan
MOORE, David Wallace
NOORANI, Ahamed Esmail
O'FLAHERTY, John Christopher
OLIVER, Rodney Michael
PARNELL, Michael David
PASHLEY, Jack Christopher
PATEL, Narhari Rambhai
PEACOCK, David Leslie
PENNY, John Edwin
PERRIN, Brian Nicholas
PHILLIP, James Whyte
PICKERING, Laurence William
RAMSAY, James Charles
RAYBOULD, Peter Edward
ROBB, Norman Garside
RODRIGUEZ, Norman William
SAMUEL, Daniel Ratnadeva
SANDERSON, John David
SANDISON, Brian John
SCOBLE, John Samuel
SKYRME, Roger Francis Beresford
SOO, Kam Weng
STOKER, Christopher John
SUTCLIFFE, John Kendrick, B.A.
TAME, David
TAYLOR, David Starkie
THAKUR, Arjun Singh, B.E.
THOMAS, Richard Vincent, B.SC.
TOMLINSON, Richard
TOWN, Ivan
VALENTINE, Peter Scott
WHEATLEY, Barry
WILLIAMS, Christopher Peter David
WILLIAMSON, David Harry Brian
YEW, Soo Peng
YOUNG, Arthur

TRANSFERS: 1st LIST

Student to Graduate

COEKIN, John Anthony, B.SC.
DRAPER, Geoffrey, DIP.TECH.(ENG.)
FERN, Derek Osmond
HARTLEY, Michael George, M.SC.TECH.
HOLT, Capt. Tonie, B.SC.(ENG.), R.E.M.E.
LANGE, Graham Warren, B.SC.(ENG.)
MABEY, David John, B.SC.(ENG.)
SMITH, John Barrington Miles, B.SC.(ENG.)
STEER, Derek Arthur Whiddon, B.SC.TECH.
STONE, Michael Thomas, B.SC.(ENG.)
WRIGHT, John Milford, B.SC.TECH.

ELECTIONS: 2nd LIST

Graduates

BRENNAN, John Patrick, B.E.
BUCKLAR, Brian George
CHADBURN, Rodney, B.SC.(ENG.)
CROSS, Charles Desmond, B.E.
DIXON, John Edward Charles
ELLIS, Robert Stanley
FLYNN, Francis Patrick, A.R.C.S.T.
FOSTER, Stephen, B.SC.

Graduates (continued)

GATES, Malcolm John, B.E.
GHOSH, Sunit Kumar, B.SC.
HEARN, Malcolm Paul, B.SC.(ENG.)
HOWARTH, David James
JONES, Harold Wesley
McMORRAN, Thomas Hamilton, A.R.C.S.T.
MACEY, John Edward, B.E.
MADUKA, Vincent Ifeanyi, B.SC.
MOHINDRA, Karunendra Kumar, B.SC.
OWEN, William Glenville, B.SC.
PEARSON, Eric
SMITH, John Edward
WELCH, Eric
WILLIAMS, Christopher Temple Sims, B.A.

Students

ADAMS, William Gordon
BALCOMBE, Hedley George
BALE, Charles Frank
BARKER, Roland Stanley
BARTER, Geoffrey Roger
BELL, John Joseph
BLACK, Brian Clements
BOFF, Malcolm George
BOWEN, Kenneth Richard
BOWLEY, George Robert
BRETT, Christopher John
BROEKHUIZEN, Willem
BUCHANAN, Richard John
BURT, Michael
CARSON, William Herbert
CLARKE, Peter James
COLLINS, John Stuart
COULBER, Roger, B.SC.
COWLES, Vivienne Christine
DAVIES, Roger Mackney
DULLEY, Terence Alexander Charles
ELLIS, David James
EVANS, Eileen Prudence
FEKETE, John Paul
FENN, Colin George
FISHER, Bryan Pearce
GHOSE, Sujit, M.SC.TECH.
GIBLIN, Roger Arthur
GILLESPIE, John Alexander
GILLINGHAM, Peter
GREEN, Colin
HARROD, James Robert
HEATH, John Edward William
HINDS, Anthony John
HOLROYDE, Anthony Basil Wells
HOMEWOOD, Robert Charles Frazer
HOSKING, Frank Vincent
HOUNSELL, Ian David
HUTTON, David John
INGOE, Anthony
JACKSON, David Gibson, B.SC.
JONES, Howard
KINDELL, Hugh Wellesley
KNOWLES, Richard Arthur
LANG, Michael Anthony Ian
McCANN, Anthony David
McCORMICK, Ian Patrick
McINTYRE, Robert Telford
MARRIOTT, Ernest Brian
MEE, David Cyril
MEEKUMS, John Robert
NEAL, John Ernest
NEWSON, Keith William
PHILLIPS, Brian Bath, B.SC.
PORTEOUS, Charles
POWELL, Ian Lawrence
PUNJABI, Lachman
REDMAN, David
RHODES, Frank
ROYSTON, David Eagland
RUSHTON, Alec James
SCOTT, Gilbert Harper
SEN GUPTA, Rabindra Nath, B.E.
SHAHIN, Mohammed Haitham
SHUTTLEWORTH, Frank
SIMMONS, Kenneth William Arthur
SMITH, Keith
SMITH, Leonard Michael
SUTTON, Anthony John
THOMAS, Derek Graham Sidney
THOMAS, Walter Eifion
THOMPSON, Terrence Edward
TIMMINS, Alan Edward
TOLLEY, Dennis James
TOMLINSON, John
TURNER, Graham Vincent
UTLEY, Cedric Ivan
WADSWORTH, James
WALKER, Terence Harold
WALTER, Conrad Homer
WHITE, James Alan
WILLBOURN, Peter
WILLIAMS, John Hywell
WILSON, Thomas Bremner

TRANSFERS: 2nd LIST

Student to Graduate

ALLAN, Andrew Garth, B.SC.(ENG.)
BADMAN, Ronald George
BENNETT, James Robert, B.SC.
BRIGNELL, John Ernest, B.SC.(ENG.)
CHARLTON, John, B.SC.
COLE, Michael Brian, DIP.TECH.(ENG.)
CUNNINGHAM, Brian Gordon
DE NEUT, Brian Anthony, DIP.TECH. (ENG.)
DUCKWORTH, Brian Gordon, B.SC.
EDLINGTON, Malcolm John Brian, B.SC.
ELLIOTT, John Richard, DIP.TECH.(ENG.)
FANNING, Philip James, B.ENG.
GILL, Alan Michael Reginald, B.SC.
HALLWORTH, Robert Philip, DIP.TECH.(ENG.)
HARVEY, Walter Thomas, B.SC.(ENG.)
HICKS, Graham John Guy
HODGKISS, Peter Keith, B.SC.(ENG.)
HOLLOWAY, David Harold
JONES, Berwyn Lloyd, B.SC.(ENG.)
KENT, Brian Hamilton, B.SC.(ENG.)
LEE, Thomas Joe
McNALLY, Donald, B.SC.
McQUEEN, Kenneth Buchanan
MAGGS, Dennis George, B.SC.
MATHUR, Hareshwar Saran, B.SC.(ENG.)
MEYER, Robert James
MILES Cyril John, DIP.TECH.(ENG.)
MILNE, Robin John, B.SC.TECH.
MORGAN, Paul Sinclair, B.SC.(ENG.)
OLLIS, Brian Edward, DIP.TECH.(ENG.)
PROBERT, Albert Ronald, B.SC.
RALPH, David Godfrey
RIGG, Barry, B.ENG.
SENIOR, Frank William, B.SC.
SHEPARD, John Glover
SIMPKIN, Laurence Edward
SMITH, Peter, DIP.TECH.(ENG.)
SMITH, Roger, B.SC.
TAYLOR, Raymond John, B.SC.(ENG.)
VERTH, Colin Carse, B.SC.
WALTON, Roy William, B.SC.(ENG.)
WATTS, Bryan Jeffrey, B.SC.TECH.
WILDRIDGE, Ernest Robert, B.SC.
WINN, Roger Frederick Edward, B.SC.(ENG.)
WYKES, Lewis Dellow

CORRECTION

IN the February 1960 *Journal*, p. 126, the corps of Capt. John Leslie Akass, B.A., should have been given as **R. Signals.**

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 10TH MARCH 1960

	No. of contributors	£	*s.*	*d.*
£1000 and over	8	8685	0	0
£100 to <£1000	32	7181	3	0
£5 to <£100	905	9448	19	3
£2 to <£5	2231	6146	10	1
under £2	28 412	14854	9	5
		£46316	1	9

ANNUAL GENERAL MEETING OF THE INSTITUTION

THURSDAY, 19TH MAY 1960 AT 5.30 P.M.

NOTICE is hereby given that the **Annual General Meeting of The Institution of Electrical Engineers** will be held on Thursday, 19th May 1960 at 5.30 p.m., at the Institution Building, Savoy Place, London W.C.2, to receive and consider the Accounts for the year ended 31st December 1959, and the Annual Report of the Council, and to elect Auditors.

Copies of the Accounts and Report (which will in due course be published in the *Journal*) can be obtained on application to the Secretary about ten days before the date of the meeting.

By order of the Council,
W. K. BRASHER,
Secretary

LECTURE BY DR. A. M. SPOONER

MEMBERS are reminded that the Annual General Meeting on the 19th May 1960 will be followed at approximately 6.45 p.m. by a lecture on 'Technical features of a new television studio at Wembley', by A. M. Spooner, PH.D., B.SC.(ENG.), ASSOCIATE MEMBER.

NOMINATIONS FOR COUNCIL VACANCIES

THE following brief biographical details of the Council's nominees for vacancies arising in the Council on the 1st October 1960 are set out for the information of members. A nomination circular is enclosed with this issue of the *Journal* to all Corporate members and Associates.

PRESIDENT (*one vacancy*)

SIR HAMISH D. MACLAREN, K.B.E., C.B., D.F.C.*, LL.D., B.SC. M. 1945. Director of Electrical Engineering, Ship Department, Admiralty. Council (1950–53, 1954 to date; Vice-President since 1955); service on principal committees of Council; Joint Committee on Practical Training in the Electrical Engineering Industry (1952–56).

VICE-PRESIDENTS (*two vacancies*)

C. T. MELLING, C.B.E., M.SC.TECH., M.I.MECH.E. S. 1920, A.M. 1927, M. 1942. Member, Electricity Council. Council (1955 to date; Vice-President since 1957); service on principal committees of Council; North-Western Centre Students' Section (Hon. Secretary 1925–26; Chairman 1926–27); Utilization Section Committee (1946–49; Chairman 1949–50); four papers published in the *Proceedings*; Students' Premium 1926; Llewellyn B. Atkinson Premium 1943; President, Association of Supervising Electrical Engineers (1952–54); Chairman of Council, British Electrical Development Association (1950–51); Chairman of Council, British Electrical and Allied Industries Research Association (1953–55); Chairman, National Inspection Council for Electrical Installation Contracting (1959 to date); Chairman, British National Committee for Electroheat (1958 to date).

B. DONKIN, B.A., M.I.C.E. A.M. 1934, M. 1940. Partner, Kennedy and Donkin. Council (1954–59); Informal Meetings Committee (1954–58); Oversea Activities Committee (1954–59); General Purposes Committee (1956–59); Membership Committee (1958–59); one paper published in the *Proceedings* (jointly).

HONORARY TREASURER (*one vacancy*)

C. E. STRONG, O.B.E., B.A., B.A I. A.M. 1933, M. 1937. Manager, Radio Division, Standard Telephones and Cables Ltd. Council (1950–53, 1957–60); service on principal committees of Council; Radio and Telecommunication Section Committee (1944–47; Chairman 1947–48); Informal Meetings Committee (1958–59).

ORDINARY MEMBERS OF COUNCIL

MEMBERS (*five vacancies*)

D. A. BARRON, M.SC. A.M. 1935, M. 1954. Deputy Engineer-in-Chief, Post Office. Electronics and Communications Section Committee (1958 to date); Informal Meetings Committee (1958 to date).

F. H. S. BROWN, C.B.E., B.SC., M.I.MECH.E. G. 1933, A.M. 1941, M. 1952. Deputy Chairman, Central Electricity Generating Board. Supply Section Committee (1956–59); one paper published in the *Proceedings*; Supply Section Premium 1954.

A. R. COOPER, M.ENG. G. 1926, A.M. 1928, M. 1946. Member, Central Electricity Generating Board. Council (1954–57); Mersey and North Wales Centre Committee (1949–52); North-Western Centre Committee (1952–55); Supply Section Committee (1953–55); service on principal committees of Council; Faraday Lecturer (1952–53); Students' Lecturer (1954–55, 1955–56); Christmas Holiday Lecturer (1957–58); two papers published in the *Proceedings*; Additional Premium 1933; John Hopkinson Premium 1948; Willans Premium 1952.

PROF. J. M. MEEK, D.ENG. G. 1929, A.M. 1939, M. 1950. Dean of the Faculty of Engineering and Professor of Electrical Engineering (Electric Power), Liverpool University. Council [1945–48 (A.M.)]; Mersey and North Wales Centre Committee (1949–55; Chairman 1955–56); Papers Committee (1946–47, 1956–57); Examinations Committee (1955–56); Research Committee (1955–57); Research Council Committee (1947–48); four papers published in the *Proceedings* (one jointly); Students' Premium 1938; Institution Premium 1942.

H. G. TAYLOR, D.SC.(ENG.). G. 1930, A.M. 1932, M. 1946. Director, British Electrical and Allied Industries Research Association. Utilization Section Committee (1955–58; Vice-Chairman 1960); Informal Meetings Committee (1939–47); seven papers published in the *Proceedings* (three jointly); Transmission Section

Premium 1939; Silvanus Thompson Premium 1937; Sebastian de Ferranti Premium 1940 (joint award).

ASSOCIATE MEMBER (*one vacancy*)

J. C. ARKLESS, B.SC. Age 33. G. 1948, A.M. 1955. Senior Contracts Engineer, A. Reyrolle and Co. Ltd., Hebburn. North-Eastern Centre Graduate and Student Section (Hon. Secretary and Treasurer 1951–52; Chairman 1952–53); North-Eastern Centre Committee (1955–58); Students' Premium 1953.

ASSOCIATE (*one vacancy*)

J. S. McCULLOCH. A. 1942. Senior Partner, Gregory and Partners. North-Eastern Centre Committee (1947–50; Hon. Treasurer 1953 to date); North-Eastern Measurement and Electronics Group (Hon. Treasurer 1954 to date); Incorporated Benevolent Fund, North-Eastern Centre (Hon. Treasurer 1950–53); Wiring Regulations Committee (1953 to date).

APPOINTMENTS AND NOMINATIONS

EAST HAM TECHNICAL COLLEGE, ENGINEERING ADVISORY COMMITTEE

The Council have nominated Mr. C. R. Stoner, B.SC.(ENG.), MEMBER, as their representative on the above committee.

BRITISH ELECTRICAL POWER CONVENTION

The Council have nominated Mr. B. L. Metcalf, B.SC.(ENG.), MEMBER, to continue to serve as their representative on the Council of the above Convention for 1960–61, and the Secretary to continue as his deputy.

JOINT ADVISORY COMMITTEE FOR ENGINEERING EDUCATION

The Council have nominated Mr. G. S. C. Lucas, O.B.E., F.C.G.I., VICE-PRESIDENT, as their representative to serve on the above committee in place of the late Mr. T. E. Goldup.

BIBLIOGRAPHICAL SERVICE

THE number of abstracts published in Section B—Electrical Engineering of *Science Abstracts* since 1947 exceeds 63000. The file in the Library of The Institution relating to these now contains over 108000 cards arranged in subject order according to the Universal Decimal Classification, and is being added to at the rate of 1000 cards a month. This file is available to members pursuing their own literature searches, but it is used mainly by the Library staff for answering written requests for information on specialized subjects within the field of electrical engineering from members who are unable to visit the Library.

A member wishing to take advantage of this service should indicate clearly the information he needs or the problem he has to solve, and if he can give the year or years in which the information may have been published, it will be helpful.

SYMPOSIUM ON ELECTRONIC-EQUIPMENT RELIABILITY

A SYMPOSIUM on electronic-equipment reliability (field experience and methods of assessing and predicting reliability) will be held on Wednesday, 18th May 1960 at The Institution of Civil Engineers, Great George Street, Westminster, London S.W.1. It is being organized jointly by the Electronics and Communications Section and the Measurement and Control Section of The Institution of Electrical Engineers. The sessions will begin at 10 a.m., 2.30 p.m. and 5.30 p.m.

The importance of reliability in electronic equipment for industrial or military use is now well recognized, and is of increasing interest to electronic-equipment designers and engineers, parts designers and manufacturers, industrial and military users of electronic equipment, and inspectors and approving authorities.

The environmental conditions which equipments for Services use must now withstand, and the massive complexity of electronic computers, are two of the factors causing concern on the score of reliability.

The need clearly exists for some means of exchanging information on all aspects of electronic reliability, and the symposium has been arranged as an initial step in meeting this need.

The sessions are entitled: 'Users' requirements and problems'; 'Problems of system design and manufacture'; and 'Problems in the design and manufacture of component parts'. The fields of application which will be covered include: armed Services and civil aviation; automatic data-processing and computers; industrial process control; radio and television receivers; and telecommunication and radar. The aspects to be dealt with comprise: reliability targets; maintenance procedures; fault identification and correction; human factors; environmental factors; methods of designing for reliability; production control; reliability assurance; active components (valves, semiconductors); and passive components (capacitors, resistors, connectors, etc.)

All who wish to attend must register. Registration forms may be obtained from the Secretary of The Institution of Electrical Engineers, Savoy Place, London W.C.2.

THE INSTITUTION CONVERSAZIONE AT THE ROYAL FESTIVAL HALL

THURSDAY, 23RD JUNE 1960

AS previously announced, an Institution Conversazione will be held at the Royal Festival Hall, London, on Thursday, 23rd June 1960 from 7.30 p.m. until midnight, and an application form for tickets was sent with the March 1960 *Journal* to all members in the British Isles. Members from oversea who will be visiting this country at the time and who wish to attend should write to the Secretary of The Institution for an application form.

Members and guests will be received by the President and Lady Jackson from 7.30 p.m. to 8.15 p.m. There will be a wide range of electrical engineering exhibits, and the programme will include a concert in the auditorium, given by the Royal Engineers Orchestra and by the Linden Singers, and dancing in the foyer, where music will be played throughout the evening by George Jay and his Orchestra. Buffet refreshments will be served from 8 p.m. to 11 p.m.

The price of tickets, which covers all charges except those for drinks obtainable at the cash bars, is £1 15s. each, and members can apply for up to four tickets in the first instance; they can also ask for further tickets, which will be sent to

them, if numbers permit, not later than the 14th May. Members of Graduate and Student Sections can obtain a single ticket for £1 or two tickets for £1 15s., but for additional tickets the normal price of £1 15s. each will apply. Evening dress, dinner jackets or uniform, and decorations will be worn.

SUMMER MEETING IN SCOTLAND, 1960

THE issue of the circular and reply form to members having been made with the January 1960 *Journal*, there has been an excellent response for the Institution Summer Meeting, which is to be held in Scotland and based on Glasgow from the 27th June to 1st July 1960. If any other members are contemplating taking part they are advised to apply to the Secretary of The Institution without delay.

An extremely varied programme of visits, excursions and evening functions has been arranged, beginning on Monday evening, 27th June, with a civic reception by the Lord Provost and Magistrates of the City of Glasgow in the famous and beautiful City Chambers and ending on Friday evening, 1st July, with a buffet-dance and cabaret. The evening functions will also include a visit to a theatre on Tuesday, 28th June, and the Institution Dinner-Dance on Thursday, 30th June.

During the week the visits will cover both the heavy electrical engineering and the electronic industries, and there will be others of a more general nature of particular interest to the ladies. There will be sailing down the Clyde, on Loch Lomond and on Loch Katrine in the Trossachs, and other excursions to the surrounding countryside.

'PROFESSIONAL CARD' ANNOUNCEMENTS BY CONSULTING ENGINEERS

THE Council have recently granted permission to a member in Australia to publish there an announcement of the 'professional card' type, in accordance with the proviso to Bye-law 42(iii)(e) which permits modifications of the provisions of that paragraph, on application, so that members practising abroad as consulting engineers may be able to conform to what is customary in the country in which they practise.

Other members similarly placed may take advantage of the concession granted by the terms of this proviso by submitting an application in writing to the Secretary of The Institution.

SCHEDULE OF ACCEPTED EDUCATIONAL QUALIFICATIONS

EDUCATIONAL qualifications at home and abroad are constantly under review by the Examinations Committee of the Council, to decide the degree of exemption which can be granted from the Institution Examination. A revised edition of the Schedule has recently been published, bearing the date January 1960, which was the time at which all the entries were up to date.

The chief alteration in the Schedule since the previous edition is the inclusion of some new Diplomas in Technology (Engineering) and revised schemes for the Higher National Diplomas and Higher National Certificates in Electrical Engineering to meet the requirements of the Joint Statement made by the Council of The Institution and the Ministry of Education in May 1958.

Copies of the Schedule are available, price 2s. each, on application to the Secretary of The Institution.

CHAIR OF ENGINEERING SCIENCE AT OXFORD

IT is announced that the Professorship of Engineering Science at the University of Oxford will fall vacant on the 1st October 1961. The electors intend to proceed to an election and invite applications by the 5th May 1960. Further particulars may be obtained from the Registrar, University Registry, Broad Street, Oxford.

ARRANGEMENTS WITH ENGINEERING INSTITUTIONS OVERSEA

MEMBERS who may have to travel abroad are reminded that in certain countries reciprocal arrangements are in operation for the extension of privileges to visiting members. The complete list of institutions concerned is as follows:

Country	*Institution*
Australia	Institution of Engineers, Australia
Austria	Österreichischer Ingenieur- und Architekten-Verein
Belgium	Société Royale Belge des Ingénieurs et des Industriels
	Société Belge des Électriciens
Brazil	Instituto de Engenharia, São Paulo
Canada	Engineering Institute of Canada
Ceylon	Institution of Engineers, Ceylon
Denmark	Dansk Ingeniørforening
Finland	Suomalaisten Teknikkojen Seura
	Tekniska Föreningen i Finland
France	Société des Ingénieurs Civils de France
	Société Française des Électriciens
Germany	Verein Deutscher Ingenieure
	Verband Deutscher Elektrotechniker
Holland	Koninklijk Instituut van Ingenieurs
Iceland	Association of Chartered Engineers in Iceland
India	Institution of Engineers, India
Italy	Associazione Elettrotecnica Italiana
	Associazione Nazionale Ingegneri e Architetti Italiana
Japan	Institute of Electrical Engineers of Japan
New Zealand	New Zealand Institution of Engineers
Norway	Norsk Elektroteknisk Forenung
	Den Norske Ingeniørforenung
Pakistan	Institution of Engineers, Pakistan
Portugal	Ordem dos Engenheiros
Rhodesia	Rhodesian Institution of Engineers
South Africa	South African Institution of Civil Engineers
	South African Institute of Electrical Engineers
	South African Institution of Mechanical Engineers
Spain	Instituto de Ingenieros Civiles de España
Sweden	Svenska Teknologföreningen

Switzerland	Schweizerischer Ingenieur- und Architekten-Verein
Turkey	Turkish Engineering Society
United States	American Institute of Electrical Engineers
	American Institute of Chemical Engineers
	American Institute of Mining and Metallurgical Engineers
United States	American Society of Civil Engineers
	American Society of Mechanical Engineers
	Institute of Radio Engineers

The Secretary of The Institution will gladly provide letters of introduction for members visiting these countries.

Forthcoming events at Savoy Place

ALL meetings are held at Savoy Place beginning at 5.30 p.m. (tea at 5 p.m.) except where otherwise stated. The nature of the meeting is indicated by the following key:

ED EDUCATION DISCUSSION CIRCLE
E ELECTRONICS AND COMMUNICATIONS SECTION
M MEASUREMENT AND CONTROL SECTION
MED MEDICAL ELECTRONICS DISCUSSION GROUP
O ORDINARY
S SUPPLY SECTION
U UTILIZATION SECTION

After each paper that has now been published is added the month when a synopsis appeared in the *Journal* under 'Papers and monographs published individually this month', i.e. about the time when the paper was published as a separate. A paper that has not yet been published will be available at least ten days before the meeting at which it will be read. The full list of London meetings is given in the meetings card

April 1960

ED **22** *Friday* PROF. H. E. M. BARLOW, PH.D., B.SC.(ENG.), will open a discussion on 'Broadening university courses'* (at 6 p.m., tea at 5.30 p.m.)

M **26** *Tuesday* T. C. CARDWELL, B.SC.(ENG.), J. R. W. SMITH, M.SC., *and* G. H. KING, B.SC. 'An experimental transistor-controlled component selection and testing machine' (paper 3219M) *synopsis:* March 1960

E **27** *Wednesday* R. CHASTE, ING.É.S.É., L.ÈS SC., *and* P. CASSAGNE ING.É.S.N.T., L.ÈS SC. 'Henri de France colour-television system' (paper 3215E) *synopsis:* March 1960

O **28** *Thursday* E. EASTWOOD, PH.D., M.SC. Lecture on 'Radar observations of birds and "angels" '‡

May 1960

E **2** *Monday* F. AXON, D.C.M., *and* O. H. BARRON, M.B.E., B.SC. 'Planning and installation of the sound-broadcasting headquarters for the B.B.C.'s Overseas and European Services' (paper 3213E) *synopsis:* see p. 236

M **3** *Tuesday* C. E. G. BAILEY, M.A., will open a discussion on 'Teaching and learning machines'†

U **5** *Thursday* S. J. EMERSON, M.ENG. Annual Lecture. 'Safety in the utilization of electricity'‡

MED **6** *Friday* W. J. PERKINS will open a discussion on 'Methods of recording measurements—digital or analogue'* (at 6 p.m., tea at 5.30 p.m.)

S **11** *Wednesday* G. JANCKE. Annual Lecture. 'The development of the 400kV network in Sweden'‡

O **12** *Thursday* J. H. MASON, B.SC., PH.D. 'The resistance of sheet insulation to surface discharges' (paper 3250M) *synopsis:* see p. 236

U **13–15** *Friday–Sunday* Section visit to Oxford

E **18** *Wednesday* Symposium on electronic-equipment reliability (field experience and methods of assessing and predicting reliability) **(at The Institution of Civil Engineers,** Great George Street, London S.W.1, at 10 a.m., 2.30 p.m. and 5.30 p.m.) (all wishing to attend are required to register; forms are available on application to the Secretary of The Institution) (see p. 253)

19 *Thursday* ANNUAL GENERAL MEETING *followed, at approximately 6.45 p.m., by* A. M. SPOONER, PH.D., B.SC.(ENG.). Lecture on 'Technical features of a new television studio at Wembley'‡

ED **20** *Friday* PROF. F. DAHLGREN will open a discussion on 'Teaching electrical engineering in Sweden'* (at 6 p.m., tea at 5.30 p.m.)

S **21** *Saturday* Section visit to Cambridge

E **25** *Wednesday* A. F. GIBSON, PH.D., *and* G. KING, B.SC.(ENG.), will open a discussion on 'New semiconductor devices and their possible applications'†

* No advance information will be available and no Press report will be permitted
† An abstract will be available in advance
‡ No advance information will be available

Contents of the current *Proceedings*

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F. W. CRAWFORD, B.SC.(ENG.), PH.D., *and* H. EDELS, B.SC.TECH., PH.D. PAPER 3185S **The reignition-voltage characteristics of freely recovering arcs** *March 1960*

T. R. MANLEY, B.SC., K. ROTHWELL *and* W. GRAY. PAPER 2835S, FEBRUARY 1959 **The application of low-pressure resins to some high-voltage switchgear designs** *January 1960*

Discussion on **The design of the 330kV transmission system for Rhodesia** before the East Midland Centre, the North Midland Centre, the North-Western Supply Group, the South Midland Centre, the Western Centre, the Northern Ireland Centre and the Western Supply Group

Discussion on **The design and performance of the gas-filled cable system** before the Western Centre, the South Midland Supply and Utilization Group and the North Staffordshire Sub-Centre

Discussion on **Examples of geoelectric surveys** before the North-Eastern Measurement and Electronics Group

Discussion on **The *Deltic* locomotive** before the North-Western Utilization Group and a joint meeting of the North Midland Centre and the Sheffield Sub-Centre

PART B. ELECTRONIC AND COMMUNICATION ENGINEERING (MARCH 1960)

See the Journal for March 1960, p. 183

PART C. MONOGRAPHS (MARCH 1960)

See the Journal for March 1960, p. 183

BULLETIN OF THE SECTIONS

UTILIZATION

Transistor inverters

On the 14th January 1960, at Savoy Place, Messrs. I. F. Davies and D. Dunthorne presented their paper entitled 'The application of power transistors to the operation of gas-discharge lamps from d.c. supplies'. An article based on the paper appears on p. 227.

The authors pointed out that, until quite recently, the operation of fluorescent tubes from d.c. supplies was attended by a high ballast power dissipation and loss of light output and also, as it was impossible to operate these lamps directly from d.c. supplies as low as 24 volts, it had been necessary for such applications to use d.c./a.c. inversion equipment, such as rotary inverters and vibrators, which suffer from the problems of wear and maintenance inherently associated with moving components.

During the last two years, however, self-driven inverters, utilizing germanium power transistors, had been developed, which not only had eliminated all moving parts but could be designed to operate from d.c. supplies of from 12 up to several hundred volts. The authors considered the design of such inverters and gave details of recent installations associated with lighting in aircraft and road and rail coaches.

In addition, an impressive demonstration was given of lighting installations using fluorescent tubes of various sizes and ratings operated from the inverters which had been described, that of particular interest being the prototype of a unit for operating a 5watt 6in. tube from a car battery.

Confidence on the railways

The discussion was opened by Mr. L. J. Garner, who, in referring to the development of transistors, remarked that their voltage rating was not rising so rapidly as that of their current, and that, as regards germanium and silicon types, 30–40volts d.c. was still about the limit. The noise factor at the high frequencies, he said, could be a nuisance, and another difficulty was the trouble which had to be taken to keep down the temperature.

Another contributor championed the cause of the square-wave inverter despite its present shortcomings and expressed the belief that it was capable of being developed to give higher efficiencies than the short-wave type.

Questions were raised concerning the relative economics of transistorized light sources and tungsten-filament lamps, and several speakers joined issue on what was really meant by 'efficiency' in lighting with these devices.

Finally it was interesting to learn from another speaker that the windows of one of the new Diesel trains of British Railways, in which he had travelled that morning, had been adorned with printed notices—presumably put up in advance—apologizing for any inconvenience due to the failure of the fluorescent lighting!

The authors adequately replied to the various points raised, and a well deserved vote of thanks was accorded to them.

R. H. R.

Annual Lecture

The Annual Lecture of the Utilization Section will be delivered on Thursday, 5th May 1960 by Mr. S. J. Emerson, who will take as his subject 'Safety in the utilization of electricity'.

Mr. Emerson is H.M. Senior Electrical Inspector of Factories and H.M. Electrical Adviser to the Home Office. He is a graduate of Liverpool University, and before joining the Home Office in 1930 as H.M. Electrical Inspector he was a distribution and transmission engineer and technical assistant to the chief engineer, Mersey Power Co. Ltd.

During the Second World War he served with the Corps of Royal Engineers for 6½ years. He held a number of appointments, including that of Deputy Chief Engineer, S.E.A.C., and was for some time Director of Machinery, South East Asia and India. He is an Honorary Colonel in the Corps.

In the Lecture, the industrial and domestic fields of electrical safety will be reviewed, the basis being practical experience in the factory and the home.

During 50 years, total electrical accidents have barely doubled, despite an increase of nearly twenty-fold in the use of electricity; and in recent years there has been a fall in accident numbers although the increase in utilization is greater than ever before.

Mr. S. J. Emerson

Statutory Acts and Regulations dating back to 1882 are briefly surveyed, and it is shown that The Institution, through the work of its Wiring Regulations Committee, has exerted a most beneficial influence throughout. As a result, the point is made that electricity is now the safest form of both industrial and domestic power.

Hazards

Hazards, where they exist, briefly fall under the following headings:

(a) Electric shock and burns
(b) Fire and explosion
(c) Eye-flash and radiations.

At the present time, when attention is focused on the national loss caused annually by fire, this risk is of special interest. Statistics are presented which clearly indicate that the number of fires from electrical causes is not rising at anything like the same rate as the total of all fires in buildings. The fire hazard from electrical causes is well under control; and the old cry, once so popular in the non-technical Press, that almost every unsolved fire was due to the 'fusing of an electric wire' has now ceased to have significance.

No lecture on electrical safety is complete without a tribute to the good work of the electrical Press, whose contribution to the educative side of safety consciousness is indispensable.

A fairly high standard of equipment and installation practice has been built up, yet many accidents are caused by the persons injured taking unnecessary risks or failing to utilize the means provided for their safety. Hence such factors as human error and mental aberration on the part of the user call for most careful consideration by those seeking to enhance electrical safety.

Summer Visit

THIS year's Utilization Section Summer Visit will be held at Oxford from the 13th to 15th May 1960. Visits will include Morris Motors Ltd., Cowley, and the Clarendon Laboratory. Full details of the Visit, together with application forms, will be forwarded separately to all members of the Section.

ELECTRONICS AND COMMUNICATIONS

Ground-wave propagation

MR. G. Millington opened a lively discussion on the subject of propagation at a meeting in the Tea Room at Savoy Place on the 8th February 1960. In his introductory remarks, which one of the later speakers suggested might have been entitled 'The confessions of Millington', our Past-Chairman gave an entertaining and provocative account of the activities of C.C.I.R. study groups on propagation.

His opinion, that the subject is far from being closed, was endorsed by most of the other speakers. Among the problems which remain to be tidied up are the details of the mode theory of ground-wave propagation, and a treatment of super-refraction showing how a duct ceases to be effective as the frequency is lowered. Perhaps most important of all was Mr. Millington's plea for the mathematician to present the results of diffraction theory in a form which will give the engineer a clear picture of the physical significance of the results.

Misleading theory

The discussion centred on the place of theory in propagation studies. Dr. Clemmow presented a strong case for continuing theoretical work and expressed the somewhat forlorn hope that propagation measurements could be made in conditions approximating to the ideal necessarily assumed by the theoretician.

Mr. Jowett, on the other hand, maintained that our knowledge of propagation effects would have developed more rapidly if there had been no theory to mislead us. Mr. Millington suggested that this viewpoint might contain some truth in relation to very high frequencies but that at lower frequencies the classical theory was extremely useful. Several speakers stressed the dangers of using the C.C.I.R. curves without careful study of the footnotes giving the conditions in which they agreed with practical results.

The audience had a most instructive and stimulating evening, demonstrating once again that the Monday-evening specialist meetings are a most valuable feature of the Section activities. The chairman, Mr. T. B. D. Terroni, closed the meeting by thanking Mr. Millington for his stimulating introduction to the subject and for the skilful way in which he had handled the discussion. J. B.

The uses of microwaves

AT Savoy Place on the 24th February 1960 Prof. A. L. Cullen gave an outstandingly successful lecture on 'Applications of microwaves' to an audience of 140 members and their friends.

He started by recalling the historical development of methods of generating and detecting microwaves, and went on to describe applications both in pure science and in engineering. In doing this he called attention to a remarkable variety of important examples ranging from precise measurements and the establishment of an atomic standard of time, to telecommunication in its many aspects.

Even microwave cooking found a place, and Prof. Cullen gave an amusing extract from a leaflet describing apparatus of this kind and trying to explain to the layman how it worked. As Mr. G. Millington subsequently remarked during the discussion, he knew that the author had taken a very active part in microwave studies but he had not realized that he had also contributed to the 'Culinary' art.

Transparent magic

As a final demonstration of the versatility of microwaves Prof. Cullen showed an experiment illustrating their application to entertainment and succeeded with masterly dexterity in persuading his audience that two pieces of cardboard could by magic words be induced to behave either as transparent or as opaque materials. Most regrettably, Prof. H. M. Barlow afterwards betrayed the secret of this achievement and thus violated one of the cardinal rules of the Magic Circle.

There was an excellent discussion following the lecture. Mr.

Lewin, Mr. Hughes, Prof. Barlow, Mr. Willshaw, Dr. Essen, Mr. Ratcliffe, Dr. Brown, Mr. Millington and Dr. Smith-Rose had contributions to make, adding much to the interest of the evening.

In particular, Mr. Ratcliffe gave some further details not generally known about the historical development of microwaves, Dr. Essen spoke of the accuracy of measurements in this field, Dr. Brown and Mr. Lewin discussed philosophical aspects of the equivalence of length and time in such measurements, and Prof. Barlow gave the results of some recent experiments on bends in low-loss helical-wire waveguide using the rotation of the wave pattern to cancel disturbances as the wave moved forward.

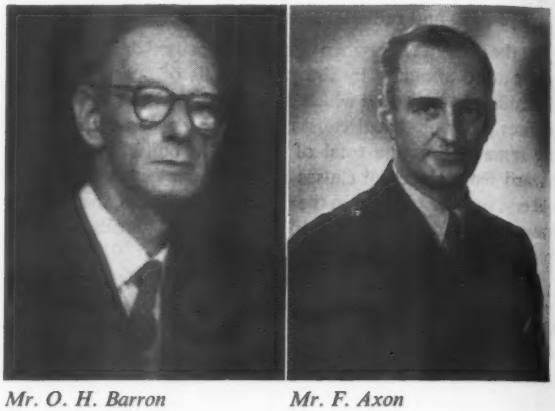
After Prof. Cullen had replied to questions the Chairman, Mr. M. J. L. Pulling, thanked him on behalf of all present for his delightful lecture, and the prolonged applause amply demonstrated the popularity of the event. H. M. B.

May meetings

On Monday, 2nd May 1960 Messrs. F. Axon and O. H. Barron will read their paper 'Planning and installation of the sound-broadcasting headquarters for the B.B.C.'s Overseas and European Services' which, after giving a brief history of the B.B.C.'s External Services, outlines the reasons for the present form of centralization at Bush House.

Mr. Axon joined the B.B.C. in 1941. He was appointed head of the Overseas and Ionosphere Sections of the Overseas and Engineering Information Department in 1949 and head of the Department in 1951. Since 1952 he has been senior superintendent engineer of the External Services.

Mr. Barron joined the B.B.C. in 1923 at Cardiff, after graduating at London University where he took a B.Sc. degree in engineering. He joined the Lines Department in London in 1929 and transferred to the Planning and Installation Department in 1941. In 1950 he was appointed head of the L.F. Studio Section which is responsible for the planning and installation of sound equipment in all B.B.C. studio and transmitter premises.



Mr. O. H. Barron *Mr. F. Axon*

On Wednesday, 25th May 1960 Dr. A. F. Gibson of the Royal Radar Establishment and Mr. G. King of Standard Telecommunication Laboratories Ltd. will open a discussion on 'New semiconductor devices and their possible applications'.

MEASUREMENT AND CONTROL

Measurements on electrical machines

At a joint meeting of the Measurement and Control, Supply and Utilization Sections, held at Savoy Place on the 5th January 1960, two papers were presented: 'A new method for observing the phenomena of commutation' by Messrs. H. J. H. Sketch, P. A. Shaw and R. J. K. Splatt and 'A method of measuring self-inductances applicable to large electrical machines' by Prof. J. C. Prescott and Dr. A. K. El-Kharashi. Articles based on the papers will be found on pp. 222 and 226.

The first paper describes a method of measuring the armature-coil current in a d.c. machine, as it reverses during commutation, by means of a search coil magnetically coupled with one of the armature coils, the output signal being integrated to give a current-wave display on a cathode-ray oscilloscope. The second paper explains special fluxmeter techniques of inductance measurement in machines.

When Prof. Prescott introduced his paper he pointed out that some of his work had been anticipated by C. V. Jones in a paper published a year previously; this is an occupational hazard for workers on the borders of scientific knowledge, but, in the view of subsequent speakers, it did not detract from the value of the paper.

Rock 'n' roll

After the authors' introduction of their papers, the discussion was opened by the Chairman, Prof. A. Tustin, who regaled the meeting with an erudite discourse on the problems of commutation. In his view, the oscillograms in the paper on commutation verified the belief that much commutator deterioration was due to brush 'rock 'n' roll'. He referred to the existing lack of knowledge on commutator difficulties as a technological scandal, and welcomed this paper as a valuable contribution to the clarification of these problems.

A prolonged and lively discussion, in which nine speakers took part, followed the Chairman's remarks. It was quite clear from the trend of the discussion that, as yet, little is known about commutation and that much work must be done in this field. Mr. J. Rea stated that, in his experience, all machines suffered from poor commutation some of the time and some of them suffered from it all the time; the only solution was to have brushless machines.

Mr. D. Edmundson commented on the singular practical value of the two papers in that the methods described could be readily used in industry. In his opinion, the fluxmeter techniques described in the second paper would prove to be

invaluable for determining transient and subtransient machine reactances.

Mr. Sketch and Dr. El-Kharashi replied in some detail to the discussion on behalf of all the authors. Mr. Sketch gave much additional information on the brush gear described in his paper, as this seemed to be a focal point of interest. A vote of thanks to the authors was proposed by Mr. T. E. Houghton, Chairman of the Utilization Section, who congratulated them on the excellence of their papers, which were short and packed with valuable information. F. C. W.

Digitalia or prestidigitation

ON the 10th February 1960 the Supply Section held a meeting under the Chairmanship of Dr. J. R. Mortlock to hear two papers on the use of digital computers in the design of transmission and distribution systems. They were 'The logical design of electrical networks using linear-programming methods' by Mr. U. G. W. Knight and 'The design of housing-estate distribution systems using a digital computer' by Dr. R. L. Grimsdale and Mr. P. H. Sinclare, which are reviewed on pp. 228 and 223.

In reading the first paper the author described work he had done first with M.A.N.W.E.B. and later with the C.E.G.B. in the production of minimum-cost designs of main-transmission and sub-transmission networks. He described two specific examples in which he had been interested, and although he stressed the help which could be given by a digital computer, particularly in assessing a multiplicity of alternative designs, he willingly admitted that the use of a digital computer did not eliminate the use of the present tools of the system-design engineer—particularly the network analyser for load-flow studies.

The second paper was presented by Mr. Sinclare of the Yorkshire Electricity Board—it had been written during his secondment to Manchester University with Dr. Grimsdale. The paper described the ingenious way in which the Mark 1 computer of Manchester University could be made to select substation sites and routes and sizes of distribution cables for housing estates. The authors were justly proud of the savings which resulted and declared that much better and quicker results would be obtained on a more modern machine.

The first swallows

The discussion was opened by Mr. T. R. Warren of the South of Scotland Electricity Board, who traced the history of planning for housing estates (especially during the post-war housing boom) which led to the publication of an electricity supply report in 1954. The cost of supplying mains and services for housing estates has now fallen, he said, from £90 each to below £50. He considered there was room for still further improvement and greater savings from the use of the new methods.

Mr. J. L. Egginton introduced some humour into the discussion by describing the computer as a powerful tool with great speed, capacity and accuracy but no intelligence, and then proceeded to demonstrate the manner in which he thought it had fallen down, by the aid of a few slides. Later on the authors were able to show that the machine had not done so badly after all.

Ten other speakers contributed to a very interesting discussion, most of which was summarized by Mr. H. J. Sheppard in saying that when the Yorkshire Board's housing-estate projects were first proposed they did not expect very much from the digital computer, but they were now happy that it could save money and, more important, the working time of highly skilled specialist engineers who could then devote their skills in other profitable directions.

Some warnings were given that engineers ought not to accept the minimum designs of the computers because the demand for electricity supply was increasing so rapidly and a little fat in the system would always be a good investment. Nevertheless these papers were not witnesses of isolated eccentricities but the first swallows that made a summer.

Mr. Knight and Dr. Grimsdale made very happy replies to the many points raised in the discussion and again emphasized that, although first savings might seem small, the new technique must now be regarded as established and further bigger developments in the saving of skilled manpower would follow.

Dr. J. R. Mortlock led the meeting in an expression of warm appreciation for a pleasant and instructive evening. G. S. B.

400 kV network in Sweden

POWER-TRANSMISSION problems in Sweden are rather special in nature, owing to the long distances between water-power resources and load centres. Consumption of electric power now amounts to 4300 kWh per inhabitant per year; about 3000 MW is transmitted and within 20 years the load is expected to increase to 8000 MW. The distances and loads have called for an extensive transmission system and its associated equipment, and the 400 kV network has met these demands economically.

Mr. Gunnar Jancke

With the growth of the system, the problems have changed in nature and the solutions have undergone modification. In particular, the increase in short-circuit power has become highly significant, since the conditions have tended to resemble

those of a concentrated network. Nevertheless, certain special considerations have not disappeared.

In his Annual Lecture to the Supply Section on the 11th May 1960 at Savoy Place, entitled 'The development of the 400kV network in Sweden', Mr. Gunnar Jancke will deal with the basic technical difficulties and their solution and provide information on the structure and development of the system and future plans.

A graduate of the Royal Institute of Technology, Stockholm, Mr. Jancke, after a short period with A.S.E.A., joined the Swedish State Power Board and is now the chief engineer in charge of research and development. He is a member of Swedish and American engineering societies and has been awarded the Gold Medal of the Royal Swedish Academy of Engineering Sciences.

He is well known for his international work on problems relating to e.h.v. transmission. He is President of the Swedish National Committee of the I.E.C. and a vice-president of C.I.G.R.É. and has rendered invaluable service to those bodies.

September Visit

Members of the Section have received the preliminary notice of the Annual Visit which is being arranged to be held from the 29th September to 2nd October 1960, in collaboration with the Western Centre. The venue is Cardiff and thereabouts.

Some of the members will undoubtedly emulate the Border invaders, who erstwhile surged from Wales into England and vice versa, in participation in visits which include Berkeley power station and the Severn Wildfowl Trust. The historic, the beautiful and the industrial aspects of Wales will also be available. These various possibilities are associated with an extremely attractive social programme which together should make the Visit full of interest and pleasure. F. C. W.

LONDON REPORT

JOINT MEETING OF THE THREE INSTITUTIONS

The Sixth Graham Clark Lecture

A JOINT meeting of The Institutions of Civil, of Mechanical and of Electrical Engineers was held in our Lecture Theatre at Savoy Place on the 3rd March 1960. At the commencement of the meeting the President, Sir Willis Jackson, cordially welcomed all present and particularly Sir George McNaughton, Vice-President of The Institution of Civil Engineers, and also Mr. W. K. Hutchison, President of The Institution of Chemical Engineers.

After disposing of some minor items of domestic business, the President formally received gifts of signature desks presented by the North-Eastern and the Scottish Centres on the occasions of their Diamond Jubilees, followed by a gift of The Institution's coat of arms worked in tapestry by Mr. G. H. Sammons, MEMBER, which has been installed as the centre panel of the decorative screen in the Lecture Theatre. These pleasant ceremonies created a very happy atmosphere. The President then invited Sir George McNaughton to take the chair for the remainder of the meeting.

Sir George McNaughton, as chairman, described how a few years ago the Councils of The Institutions of Civil, Mechanical and Electrical Engineers decided to arrange a series of annual lectures on subjects of cultural interest to the members of all three institutions. The suggestion was originally put forward by Mr. Graham Clark, Secretary of The Institution of Civil Engineers from 1937 to 1954, and, after his death on the 23rd April 1954, it was decided to perpetuate his name by calling the lectures the Graham Clark Lectures.

Mr. Graham Clark played a leading part in furthering the close relationship which now exists between the three institutions and in promoting active co-operation between the principal engineering societies not only of the Commonwealth but also of Western Europe and the United States.

Counterpoint and harmony

The chairman then introduced Sir Hugh Beaver, whom he called on to deliver the Sixth Graham Clark Lecture. Sir Hugh has been managing director of Arthur Guinness, Son and Co. since 1946. During the Second World War he was Director-General in the newly created Ministry of Works and was responsible for the planning and control of the building and construction industry. After the war, he was a member of the New Towns Committee which laid down the pattern and principles on which new towns have been built. He was, from 1954 to 1956, Chairman of the Advisory Council of the Department of Scientific and Industrial Research, and from 1957 to 1959 was President of the Federation of British Industries and of The Institution of Chemical Engineers.

Taking as his subject 'Engineering and civilization', Sir Hugh Beaver covered in his Lecture a very wide field. He

The President thanks Mr. Sammons

opened with a tribute to Graham Clark, and then dealt with the tendency in our age towards narrowing specialization and the resulting fragmentation and proliferation of engineering societies, and with the efforts made to counteract some of their effects. Those engaged in science and technology have at least a common purpose, to serve civilization, and the present series of Lectures was designed towards the formulation in our minds of what our own long-term philosophy should be. Newly emerging factors such as the staggering rate of growth of population, and potential world destruction, compel this.

Sir Hugh Beaver delivering his Lecture

Against this background, engineers have a special responsibility. Many perplexing problems arise relating both to the nature of things and to the nature of man which, unless we read their riddles aright, must cause us to face the extinction of civilization and perhaps of mankind. Alternatively, the prizes are great, for engineering can bring untold benefits to the world. To win them we must carefully consider our whole educational system in an age of technology and adjust the balance of its needs. To this the great institutions should give continuous thought.

This brief outline cannot in any way convey the richness of the thought which adorned Sir Hugh's Lecture, nor the cultured excellence of the elocution with which it was delivered. The counterpoint of its various themes and the harmony of its expression in themselves gave real pleasure. Printed copies of the Lecture, which were afterwards made available, fittingly recorded a memorable occasion. The full text of the Lecture will be found on p. 205.

A hearty vote of thanks to Sir Hugh Beaver, proposed by Sir Willis Jackson and seconded by Sir Hamish MacLaren, was carried with acclamation. J. K. W.

ORDINARY MEETING

Avoiding the lightning strike

At the Ordinary Meeting at Savoy Place on the 4th February 1960 the Chair was taken by the President, who extended a special welcome to the young author of the Supply Section paper on 'The shielding of overhead lines against lightning'. Dr. J. H. Gridley's article based on his paper appears on p. 221.

In his presentation, Dr. Gridley postulated that, if at least as many lines of force terminated on the earth conductor as on the phase conductor, there was an equal chance of producing an upward leader from either. This gave a criterion for positioning the earth wire.

45° too large?

The ensuing discussion, in which the author came under some heavy (St. Elmo's?) fire, was opened by Dr. J. S. Forrest, who remarked that lightning was still the greatest single cause of breakdowns in overhead-line systems. Dr. Gridley had made an advance in the theoretical treatment of the shielding problem, but the practical outcome, a 45° shielding angle, was a little disappointing. That, after all, was no different from British Standard lore of 20 years before; further back still, Benjamin Franklin had shrewdly thought likewise. He invited the author to comment on the unexpectedly high fault rate for the 275kV Grid: 1·6 per 100 route-miles per annum.

Other speakers produced factual evidence that 45° is too large, and figures of 30° and even 20° were mentioned. One contributor criticized the assumption of a vertical leader in the calculations, arguing that the leader would never be vertical over its most influential part. From statistical considerations this would reduce the safe shielding angle. Another called attention to the effect of conductor swing and felt the good theoretical content was not fully matched by the statistical evidence presented.

The author replied briefly but firmly to many of the points: he was unrepentant and welcomed the critical content of the discussion.

Members' approval was heartily shown on the proposal made by Dr. J. R. Mortlock, Chairman of the Supply Section.

D. F. O.

DISTRICT MEETING AT OXFORD

Automation on the telephones

At a District Meeting held at the Southern Electricity Board's Offices on the 9th March 1960, Mr. H. E. Francis, staff engineer of the Engineer-in-Chief's Office of the Post

Office, gave a talk on 'Automation of the national telephone system'.

His extremely interesting discourse, illustrated by slides, dealt with subscriber trunk dialling and the problems of formulating a national dialling code. He explained how the calls would be routed through the fully automatic exchanges. A new method of unit charging would have to be introduced, and all calls would be metered in much the same way as the electricity supply. It is a proof of the advantages of subscriber trunk dialling that, in the Bristol area where it was recently introduced, only 2% of the calls are handled by the operators.

After a refreshment interval, Mr. Francis dealt very ably with the many questions that were put to him. Mr. W. F. Sands proposed a vote of thanks on behalf of the 54 people present, complimenting the lecturer on the easy and lucid manner in which the talk had been given. D. T. H.

News from abroad

QUEENSLAND OVERSEA COMMITTEE

Christmas luncheon

THE annual luncheon for 1959 was held at the Maple Lounge, Brisbane, on the 8th December and was attended by some 33 members. The new location proved very popular both because of its accessibility and because the air conditioning ensured a high degree of comfort in summer conditions.

After the loyal toast Mr. A. S. Faulkner introduced the guest speaker, Mr. F. B. Haigh, who is Commissioner, Irrigation and Water Supply Department, Queensland. Mr. Haigh spoke of the policy and pursuits of his department in relation to development of the State.

A vote of thanks to the speaker was moved by Mr. E. Morwood, and in closing the proceedings Mr. Faulkner extended the season's greetings to those present. W. I. G.

TRINIDAD AND TOBAGO JOINT GROUP

Cathodic protection

ON the 18th February 1960 there was a meeting to hear a paper 'The practical application of cathodic protection for pipelines and marine structures' by P. Cherry.

Mr. Cherry has specialized in protection engineering for a number of years and is on his second extended visit to Trinidad. During these visits he has investigated and executed a number of schemes for cathodic protection. His paper dealt with these schemes, and the results obtained to date, and also with the particular problems encountered in Trinidad. The economic and practical aspects of various methods were discussed and the development of new alloys for use as electrodes received attention.

With the growth of offshore oil-well drilling in Trinidad, the question of the protection of marine structures has become very important, and the gathering was attended by over 60 members and their guests, many of whom not only asked questions but also made useful contributions during the ensuing discussion.

The meeting was held in Port-of-Spain, and afterwards members adjourned to the 'Pelican Inn'—a newly opened English-style 'pub'—where the traditional dishes of bread and cheese, pork pies, etc. were enjoyed for supper.

This was the first of a series of functions arranged by our newly appointed Programme Secretary, Mr. David Key, A.M.I.C.E., and was one of the most successful events ever organized by the Joint Group. D. P. J. H.

BRITISH GUIANA JOINT GROUP

Meetings in 1959

AT the meeting on the 4th July 1959 it was decided to hold monthly meetings, and for the remainder of the year the Group ran to a monthly programme at which members gave informal talks on the work on which they were engaged in the Colony. The talks presented were as follows: 'Drainage and irrigation works constructed within the past six years in the Colony' by D. S. Fairbairn, A.M.I.C.E., and P. J. Drury, A.M.I.C.E.; 'Sea defences' by S. S. Naraine, A.M.I.C.E.; 'Development in welding techniques' by S. G. Wilson, A.M.I.MECH.E.; 'Aspects of the construction of the bulk-sugar terminals' foundations' by R. E. Tuckwell, A.M.I.C.E.; and 'Basic principles of telecommunications reconstruction scheme' by P. A. Brown, A.M.I.E.E.

During the year a site visit was arranged to the bulk-sugar terminals now under construction for the sugar industry in British Guiana. D. S. F.

MIDDLE EAST JOINT GROUP

Water in Abadan

ON the 14th and 15th January 1960 the Group held a most successful meeting in Abadan, at which the Association of Iranian Engineers in Abadan acted as hosts. After tea, the meeting began with a paper by J. J. Johnston, A.M.I.C.E., and J. D. McManus, A.M.I.C.E., on the raw-water supply in Abadan.

The reading of the paper was attended by some 150 members and guests, and afterwards there was an excellent buffet supper at the kind invitation of the Iranian Oil Refining Co. Ltd.

On the morning of the 15th January, members and guests made an extensive tour of the raw-water installations, which proved most interesting and instructive. The tour was followed by a much-needed luncheon kindly provided by the National Iranian Oil Co. D. W. P.

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